A RAND NOTE

TSAR User's Manual—A Program for Assessing the Effects of Conventional and Chemical Attacks on Sortie Generation: Vol. II, Data Input, Program Operation and Redimensioning, and Sample Problem

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PREFACE

This Note is one of a four-volume set that collectively describes the latest versions of the TSAR (Theater Simulation of Airbase Resources) and the TSARINA (TSAR INputs using AIDA) computer models, which were developed at The RAND Corporation to assess the sortie generation capabilities of airbases and the effects of airbase attacks on those capabilities. These new versions replace earlier versions, including the versions documented in 1985. Among the more significant new features are those that permit representation of (1) austere dispersed operating bases, (2) attacks on the minimum operating surface (MOS) chosen after prior attacks, (3) multistep parts and equipment repairs, (4) repair of damaged aircraft shelters, (5) improved fidelity in the runway repair representation, and (6) damage generated by the delayed detonation of unexploded ordnances (UXOs). This development was carried out under the Project Air Force Resource Management Program project entitled "TSAR/TSARINA."

The TSAR model provides an analytic context within which a variety of airbase improvements may be tested. New passive defenses, new chemical defenses, new maintenance doctrine, improved base repair and recovery capabilities, increased stock levels for parts and equipment, and concepts for improved theater-wide resource management can be examined for their effect on aircraft sortie generation. The TSAR model has also proven useful for evaluating initiatives that would improve weapons and weapons delivery systems, enhance multibase support, upgrade the reliability and maintainability of new aircraft designs, and revise training curricula to broaden the capabilities of maintenance specialists. These models have been briefed to several Air Force organizations during the development process, and are currently in use at several Air Force agencies, aerospace corporations, and at selected overseas sites.

This volume of the *User's Manual* should be useful primarily to those persons responsible for preparing input materials and for operating the TSAR simulation program. The companion Notes include:

N-3010-AF *TSARINA—A Computer Model for Assessing Conventional and Chemical Attacks on Airbases*

N-3011-AF *TSAR User's Manual—A Program for Assessing the Effects of Conventional and Chemical Attacks on Sortie Generation: Vol. I, Program Features, Logic, and Interactions*

N-3013-AF *TSAR User's Manual—A Program for Assessing the Effects of Conventional and Chemical Attacks on Sortie Generation: Vol. III, Variable and Array Definitions and Other Program Aids*

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FIGURES

TABLE

GLOSSARY

ABDR	Aircraft Battle Damage Repair
AGE	Aerospace Ground Equipment and other support equipment used for carrying out maintenance and repair tasks
AIDA	AIrbase Damage Assessment model; the forerunner of TSARINA
AIS	Avionics Intermediate Shop; special test equipment used for repairing avionics LRUs and SRUs
AMU	Aircraft Maintenance Unit; the organization providing maintenance for an aircraft squadron
APG	Airframe-Propulsion General
ATC	Air Traffic Control
BKEP	Ballistic Kinetic Energy Penetrator
BLSS	Base-Level Self-Sufficiency stock of aircraft spare parts, composed of the stocks for peacetime, plus additional material to meet wartime demands
CAP	Combat Air Patrol
CAS	Close Air Support
CBU	Cluster Bomb Unit
CILC	Centralized Intermediate Logistics Concept
CIRF	Centralized Intermediate Repair Facility
COB	Collocated Operating Base
COMO	Combat-Oriented Maintenance Organization
CONUS	Continental United States
CPS	Collective Protection Shelter
CRS	Component Repair Squadron; a wing-level organization responsible for parts repair
CW	Chemical Warfare
DOB	Dispersed Operating Base
EMS	Equipment Maintenance Squadron; a wing-level organization responsible for equipment maintenance and repair
FRAG	FRAGmentary order that specifies flight requirements

GP	General-Purpose bomb
ILM	Intermediate Level Maintenance; on-base parts repair supporting the AMU
IPE	Individual Protection Equipment for a chemical environment
JCL	Job Control Language
LCOM	Logistics Composite Model
LRU	Line Replaceable Unit; an aircraft spare part with distinguishable subordinate components
MOB	Main Operating Base
MOPP	Mission Oriented Protective Posture (the chemical protection ensemble)
MOS	Minimum Operating Surface for flight operations
NMCS	Not Mission Capable because of lack of Spare parts
NORS	Not Operationally Ready because of lack of Spare parts; term previously used for NMCS
NRTS	Not Reparable This Station
OST	Order and Ship Time in days; time for a NRTSed or condemned part to be replaced
PAA	Program Authorization, Aircraft
POL	Petroleum, Oils, and Lubricants; often used as an abbreviation for aircraft fuel
POS	Peacetime Operating Stock; an organization's stock of aircraft spare parts for aircraft maintenance in peacetime
QPA	Quantity Per Aircraft; the number of parts of a particular type on each aircraft
QRA	Quick Reaction Alert
RAM	Rapid Area Maintenance; special mobile teams used for repairing aircraft battle damage
RR	Flight line maintenance concept that removes and replaces malfunctioning aircraft parts with serviceable components; generally implies no local repair
RRR	Flight line maintenance concept that removes, repairs, and replaces aircraft spare parts (actually, usually removes and replaces with a serviceable unit, and then repairs the malfunctioning unit)
RRR	Rapid Runway Repair

SAMSOM	Support Availability Multi-System Operations Model
SCL	Standard Combat Load that designates the aircraft configuration and the mission-dependent munitions to be loaded
SE	Support Equipment, usually referred to as AGE in TSAR
SRU	Shop Replaceable Unit; a component of an LRU
TBM	Tactical Ballistic Missile
TRAP	Tanks, Racks, Adaptors, and Pylons
TSAR	Theater Simulation of Airbase Resources
TSARINA	TSAR INputs using AIDA
UXO	Unexploded Ordnance
WRM	War Reserve Material
WRSK	Wartime Readiness Spares Kit
WUC	Work Unit Code

XVI. INTRODUCTION

Volume II of the *User's Manual* is intended primarily for those responsible for preparing input materials and for operating the TSAR (Theater Simulation of Airbase Resources) computer simulation model. Volume III will prove useful for those interested in modifying and extending the program logic, or in trying to understand apparent errors.

TSAR is a Monte Carlo discrete-event simulation model designed for analyzing the interrelations among the resources associated with a set of airbases, and the capability of those airbases to generate aircraft sorties in a dynamic wartime environment. On-equipment maintenance tasks, parts and equipment repair jobs, munitions buildup jobs, and facilities repair tasks can be simulated for each of up to 63 airbases. Intratheater transportation, communication, and resource management may also be simulated. Asset accounting for each of 11 classes of resources, and for several types within each class, permits assessment of a broad range of policy options that could improve the efficiency of resource utilization on a theater-wide basis. With the companion TSARINA (TSAR INputs Using AIDA) airbase attack simulation model, TSAR can be used to examine the sortie generation of a set of airbases subjected to a campaign of conventional and chemical attacks.

An important objective in the original design formulation of TSAR was to achieve a sufficiently high speed of operation that the extensive (often trial and error) sequence of runs so frequently necessary in research and analysis would be economically practical. Adaptation of existing models (e.g., LCOM, SAMSOM) was rejected for several reasons, including the extent of the modifications that would have been required and the prohibitive costs that would be associated with their use for problems of the size that were contemplated. The initial phase of development was designed to test the hypothesis that speed would be improved if custom-tailored list processing techniques were created using the widely available FORTRAN language, rather than standard simulation language packages, and if full advantage were taken of the large amounts of directly accessible computer memory that are now available. The resultant custom-designed program achieves a substantially higher speed than previously developed simulation models of equivalent and lesser complexity.

In its current formulation, TSAR makes no intermediate use of auxiliary high-speed storage units (e.g., disks, tapes) except for storing the initial conditions for multiple trials and the damage results generated by the companion TSARINA model. To constrain the substantial computer storage requirements generated by this design approach, all but a handful of the program variables and array elements occupy only two bytes of core, and many of the array elements are packed with two and sometimes three, four, or even five pieces of information.

TSAR now consists of 198 subroutines and 18 functions (with 328 entry locations); the source code consists of over 70,000 card images, exclusive of those required for the common statements. Without the space required for the data storage arrays, approximately 1000 K bytes are required for the program, when the overlay structure illustrated in App. K of Vol. III is used. If certain features are not to be used (e.g., airbase attack, chemical warfare effects, theater management of aircraft or other resources, and parts initialization), this requirement can be reduced by overlaying the subroutines associated with the unused features. For the substantial dimensions specified for the current load module, another 5275 K bytes are required for data storage. However, many useful applications of TSAR would require only an additional 500 K bytes for storage (see Sec. XVIII). All data that would be needed to resume operation in the event processing was interrupted (as might be done, for example, if one wished to adapt the program for interactive operation) are in COMMON statements.

OUTLINE OF MATERIALS

The materials in this volume and the extensive comments included in the TSAR source code[1] are designed to help those responsible for preparing input materials and for operating TSAR. The next section outlines the classes of resources that TSAR can deal with and discusses certain built-in numerical constraints that the user must observe. Section XVIII outlines the procedures that are to be used in restructuring TSAR storage space for each user's special requirements. Because all data are retained in core during execution, core management discipline will dictate occasional program redimensioning, when the character of the situation to be simulated changes greatly.

[1]The TSAR source code will be made available to qualified agencies on magnetic tape.

Section XIX is the *key source of information for the use of TSAR*; it is the *only* location in which *all* of TSAR's features and controls are explained. Section XIX provides extensive discussions and explanations of the appropriate data entry procedures for the 50-plus data entry formats that are used with TSAR. Each discussion presents a copy of the data input format and sample entries to illustrate the use of each form. When options exist, each is illustrated.

A special sample problem has been developed to illustrate TSAR's many features, the data entry procedures, and the appearance of TSAR output. This sample is introduced in Sec. XX; the situation simulated (with a few exceptions and modifications) is defined by the same data that are introduced piecemeal in Sec. XIX to illustrate the input procedures. Section XXI presents portions of the computer output listing for this sample problem and illustrates the various kinds of information that can be obtained. Section XXII provides a checklist for TSAR input data requirements that can be used in conjunction with the format specifications in Sec. XIX when the user is developing or modifying a TSAR input data set.

Appendix A in Vol. III lists the name and purpose of each TSAR subroutine. Appendixes B and C present full alphabetical listings, with definitions, for all control variables and for all data storage arrays that are contained in any of TSAR's common statements. These will be helpful for better understanding the discussions in the *User's Manual* and for gaining a more detailed understanding of TSAR's data structure; they will be essential for anyone who works with the source code.

The other appendices in Vol. III present the changes required to convert earlier TSAR data bases, a copy of the load module map that indicates in which subroutine each entry point can be found, copies of three auxiliary programs, a list of the available probability distributions, instructions for introducing the effects of a ground attack, and three sets of Job Control Language that can be used to compile, link-edit, and execute the TSAR program.

DATA REQUIREMENTS

TSAR input data requirements naturally depend upon the level of detail at which the simulation is to be conducted and the features that are to be used. Many sources are available that can contribute to these requirements. Of the different types of data, probably the most complex and difficult to obtain are those that define the demands and

resources for unscheduled maintenance and parts repair for different types of aircraft. Fortunately, many of these data are collected on a regular basis by the Air Force for various purposes, including spare parts provisioning and manning studies.

In addition to several data bases developed at The RAND Corporation for use in our tests and applications of TSAR, several Air Force agencies using TSAR/TSARINA have contracted for a variety of important data base developments. Included among these groups are the Air Force Center for Studies and Analysis, the Air Base Survivability Management Office, and the Air Force Human Resources Laboratory.

XVII. RESOURCES, DICTIONARIES, AND NUMBERING SYSTEMS

Eleven distinct classes of resources may be monitored using TSAR, but only aircraft are mandatory. Several "types" of each "class" of resource may be distinguished. The 11 classes of resources, the number used to identify each class, the arrays in which their status is stored, and the restrictions on the numbers of types and the numbers of resource units of each type are shown below; the maximum number of units that may be shipped in any particular lot is also indicated for each class. These restrictions are the upper limits imposed by the manner in which data are packed in data storage arrays; lower limits may be imposed by the dimensions of the storage arrays.

Resource Class				Maximum Number	Maximum Number
Name	Number	Storage Array	Maximum Number of Types	per Type per Base	Shipped per Lot
Aircraft (ac)	8	ACN	9	999	250
Aircrews		PILOT	1 per ac type	—	250
Ground Personnel	1	PEOPLE	320	320	250
AGE and Equipment	2	AGESTK	320	320	250
Parts (LRU,SRU)	3	PARTS	9999	320	250
					250
Munitions (including components)	4	MUNSTK	320	32000	6250
TRAP	5	TRAP	320	32000	6250
Building Materials	6	MATERL	99	32000	250
POL	7	POLSTK	1	32000	$250 \times (10^2)$
Aircraft Shelters	na	SHELTS	3	total of 111	—
Taxiway Segments	na	ARC	1	399	—
Aircraft Ramps	na	RAMPS	1	111	—
Other Facilities	9	FACLTY	399	1	—

The status data maintained for each of these several classes of resources are listed in the corresponding storage arrays as described in App. C, Vol. III. Aircraft, aircrews, fuel trucks, facilities, and reparable spare parts and equipment are monitored on an individual basis; all others are handled in more aggregated terms. The level of detail

varies from that maintained for an aircraft—potentially several dozens of items of information—down to the total amount of POL available at each airbase.

Although not explicitly treated as a resource (except insofar as physical damage may be reflected in the FACLTY array), the work-centers, or shops, on each base are the entities around which aircraft maintenance activities and the parts and equipment repair activities are organized. Except for civil engineering jobs, all ongoing, interrupted, and waiting jobs are locatable using the pointers stored in the SHOPS array; as noted in App. C, Vol. III, that array stores 28 data elements for each shop on each base. TSAR storage arrays are sized for a maximum of 30 shops, the last 5 of which are reserved for preflight tasks and weapons assembly jobs.

The subroutines that prepare resources for intratheater shipment (SHPRES) and that receive intertheater and intratheater shipments (DOSHIP), are written to accommodate ground personnel, equipment, parts, munitions, TRAP, building materials, and POL. However, the only theater resources that are actually transferred within the theater using the current theater management logic are aircraft, ground personnel, equipment, and parts; all resources may be received from CONUS. Similarly, the program logic permits aircraft and spare aircrews to be ferried to the theater from CONUS, and allows aircraft to be ferried from base to base within the theater for maintenance and to be directed to land at a base that is not the one from which they are launched on a combat sortie.

One of the first tasks in developing a TSAR data base is to develop dictionaries of the various categories of resources that are to be simulated. Each type of aircraft, personnel, equipment, spare part, munition, TRAP, and building material must be identified with a number that is also the location in the data storage array where the information regarding the particular type of resource is located; the ACDATA, PEOPLE, AGE, PARTS, MUNSTK, TRAP, and MATERL arrays are used for these seven classes of resources. It is the user's responsibility to see that the resource types in a given class have different numbers and that none of those numbers exceed the dimension of the relevant array (i.e., do not exceed MAXT, NOPEOP, NOAGE, NOPART, NOMUN, NOTRAP, and NOMATL; the values of these dimensions for a user's load module are listed in SIZES parameter statement). It is also the user's responsibility to see that the numbers used to designate personnel, equipment, parts, etc., in the task specifications for TSAR correspond to the resources as defined in the stockage arrays.

Probably the best way for a user to develop an internally consistent data base is to build a dictionary with a list of the TSAR identification numbers and the normal Air Force designations for the members of each resource class, and to consult these lists as often as necessary to avoid the confusion that tends to arise when using the arbitrary TSAR numbering systems for otherwise familiar items. The dictionary created for the sample problem in Sec. XX is shown in Fig. 15 of that section.

All locations on an air base also must be identified by a number. Each building has a "facility" number. Similarly, each segment of the taxiway network (including all components of each runway) is numbered, and each aircraft shelter and each aircraft parking ramp are also numbered; these latter three sets must be numbered according to the order in which the corresponding TGT (target) cards are entered in the TSARINA data base; a separate numbering sequence is used for each of the three sets. Taxiway, aircraft shelter, and ramp data are stored in the ARC, SHELT, and RAMP arrays, and data for all other structures are described in the FACLTY array. The rules for numbering structures are quite specific. Numbers between 1 and 50 may be used only with the definitions shown in Sec. VIII, Vol. I; the numbers (i.e., the columns of the FACLTY storage array) between 51 and NOFAC may be selected to represent portions of distributed repair shops, distributed assembly areas for unassigned squadron personnel, distributed munitions assembly areas, and sets of collective protection shelters.

XVIII. DIMENSIONING AND REDIMENSIONING

For many study applications it will be appropriate and necessary to redimension various portions of TSAR's data storage arrays. All the arrays are listed below, and their dimensions are defined in terms of variables that are in COMMON (see App. B, Vol. III). When the user's data demand a different amount of space for storage, or if the problem can be projected to require a substantially different amount of space for queuing the internally generated event data (e.g., tasks in process, interrupted, and waiting), the dimension can be changed in all necessary locations by changing it once in the appropriate PARAMETER statement. Definitions of the variables used to dimension these arrays, and the arrays themselves, are listed alphabetically in Apps. B and C, respectively, in Vol. III.

All storage arrays and dimension statements are located in one of 33 labeled COMMON statements or in the SIZES dimensioning statements. These statements are inserted into the appropriate subroutines by referring to their actual storage location so that only one copy of SIZES and each Common Statement exists and only one change is required to redimension any given array in all the locations in which it ultimately appears. This process is specifically outlined in the comments in the INIT subroutine.

The dimensions of all arrays in all COMMON statements are shown in the list that follows; all dimensions that are specified with a program variable may be modified by the user. The appropriate value for many of the array dimensions will be uniquely identifiable by the nature and data of the user's problem. However, the dimensions needed for the data generated dynamically during the simulation are not knowable, a priori. Some experience with the particular application will be needed if space is to be conserved and data (tasks, jobs, shipments, etc.) are not to be lost; OVERFL permits the user some flexibility for dealing with this problem. The temporary queues in subroutine DELAYS may also overflow, but a warning to that effect is printed. Arrays with deterministic requirements are in the first of the following lists; the queues and heaps are listed second.

Many of the arrays are dimensioned by MAXM, MAXT, and MAXB—i.e., the maximum numbers of missions, aircraft types, and bases.

These dimensions are abbreviated here as	M,	T,	and B.
The limits for these dimensions are	5,	9,	and 63.

DATA STORAGE ARRAYS

ACA(3,M,T,B)	ACATC(3,50)	ACDATA(36,T)
ACMDTA(20,M,T)	ACCODE(B,T,2)	ADELAY(25,2,B)
AGENT(3,10,3,3,2)	ACN(MAXACN,50)	AGERPT(NOAGE,B)
AGERQT(NOAGE,M,T)	AGEREP(NOAGER,7)	AIDALT(T)
AISDTA(NOSTAT,5)	AGESTK(NOAGE,3,B)	ALERT(6,M,T,B)
ALTAGE(NOAGE,3)	AISUSE(NOSTAT,6,B)	AQPEOP(NOPEOP,5)
ARC(NOARC,9)	ALTPEO(NOPEOP,3)	ATCPT(5,B)
ATTACK(LTHATT,5)	ATCLOC(3,6)	ATTNUM(500)
AVGP(3,30,B)	ATTDLY(2,B)	AVGSHP(B)
AVGTSK(25,T)	AVGREP(25,T)	BADFIT(10,NOMP)
BASDTA(12,B)	BADCAN(NOPART)	BCSTAT(4,B)
BORROW(NOUSER,2)	BASES(60,B)	BSESOR(B)
BSHELT(MXSHL)	BPARTS(15,T,B)	BUDDY(NOPEOP+T,4)
CANCEL(5,T,B)	BSOR(B)	CANNTM(NOPART)
CARGO(NCARGO,2)	CANFLY(3,M,T,B)	CERQTS(10,NOCE)
CHCKED(NOPART)	CEPRTY(NOFAC,B)	CKFILL(T)
CMCL(B)	CIRFTM(25)	CONFIG(NOCONF,10)
CONUS(NOCONS,2)	CMCW(B)	CRBLDG(B)
CSTOCK(NOPART,2)	COSTS(NOPART)	CTPEOP(NOPEOP,5)
CURE(10,8)	CTPEO(NOPEOP)	CWATTK(15,B)
CWFAC(NOFAC,3)	CWARC(MXARC,3)	CWOUT(24,B)
CWPROT(8,10)	CWMET(5,12,20)	CWSHEL(MXSHL,3)
CWTYP(30)	CWRAMP(MXRAMP,4)	DAYNIT(NOPEOP)
DEHYD(6,3)	DAMAGE(NOITEM,2)	DEPOT2(NOAGE)
DEPOT3(NOPART)	DEPOT1(NOPEOP)	DEPOT5(NOTRAP)
DEPOT6(NOMATL)	DEPOT4(NOMUN)	DEPOT9(T)
EXTRAK(6,B)	DEPOT8(T)	DUPFAC(NOFAC,B)
FACLTY(14,NOFAC,B)	FACDAM(NOFAC,7)	FACLTE(NOFAC,B)
FRAC(NOFAC)	FILLER(T,2)	FIXARC(NOFIX,5,B)
FUELOD(3,B)	FRACBS(NOPART,B)	FRACJB(NOFAC)
HITAID(4,MXARC)	FUELER(40,B)	GTLMT(NOPART)
INPIPE(NOPART,B,2)	HITRMP(2,MXRAMP)	HURRY(B,5,2)
JOBDTA(20,2)	IPIPE(NOPART,2)	ITEMS(B)
LATERL(B)	JOBPR(2,T)	LANDNG(B)
MATERL(NOMATL,B)	LISTIN(LTHLST)	LTH(5)
MOPMOP(10,2)	MAXOFF(2,T)	MEDICS(10)
MPDOSE(3,2,NOMP,B)	MOPPOL(6)	MPARR(NOMP)
MPHIT(LTHCWH,8)	MPDOSO(3,2,NOMP)	MPDOST(3,10,NOMP,B)
MUNCOM(NOWEAP,10)	MPOINT(B,NOMP,2)	MPPERS(LTHPER)
MUNRQT(5,NOBILD)	MUNRED(NOWEAP,NOWEAP)	MUNRQD(NOWEAP,M,T)
NOAMMO(M,T,B)	MUNSTK(NOMUN,4,B)	MXPHAS(T)
NOMINI(NOPART)	NODE(NONODE,2)	MXTASK(9)
NORHRS(B)	NOR(B)	NODES(15,B)
OFFCOB(NOPART,T)	NSTAT(NOSTAT,2,B)	NORBD(B)

OUTEQP(2,NOAGE,B)	OFFMOB(NOPART,T)	OFFBSE(2,50,2,T)
OUTMUN(2,NOWEAP,B)	OUTFAC(2,30,B)	OUTAGE(2,NOAGE,B)
OUTPOL(2,B)	OUTPEO(2,NOPEOP,B)	OUTMAT(2,NOMATL,B)
OUTTRP(2,NOTRAP,B)	OUTPRT(2,NOPART,B)	OUTPER(2,NOPEOP,B)
OUTPT3(2,M,T,B)	OUTPT1(5,6,M,T,B)	OUTSHP(9,30,B)
OWORST(10)	OUTPT4(2,30,M,B)	OUTPT2(3,3,25,B)
PEOPLE(NOPEOP,10,B)	PARTRQ(NOPART,T)	OUTPT5(5,30,B)
PERIOD(20,3)	PEORPT(2,NOPEOP,B)	PARTS(NOPART,5,B)
PHASED(100,T,2)	PILOT(6,NOCREW)	PEORQT(NOPEOP,M,T)
PLIST(3,75,B)	POLSTK(B)	PILOTS(5,T,B)
POLICY(NOPART,B,2)	+PRTLST(NOPRT)	PROTEC(2,4,B)
PRTCRT(NOPRT,2)	PTZ(M,T,B)	PRTRPT(4,NOPART,B)
PRTRQ(NOPART,2,T)	READY(30,B)	RAMPS(4,NORAMP)
RCLEAR(B)	REFILL(2,9)	RECORD(NSCROL,3,MAXREC)
REDUCE(B,5,2)	REPALT(NOREPA,4)	RELIMP(33,5)
REPAIR(B,200)	RINDEX(4,B)	REPORT(NOREPT,4)
+REPRQT(NOREP,9)	RQDMOP(2,5,3,2)	RINDX(48,B)
RNWYZ(5,B)	RWYDAM(20,8,B)	ROOTS(NOPART,T)
RWYARC(NORARC,2)	SAVE(B,5,2)	RWYNOD(2,B)
RWYREP(15,B)	SEEDED(10)	SCLP(10,M,T,2)
SCLRQT(NOSCL,11)	SHELTS(10,B)	SEEDS(10)
SHELT(NOSHEL,6)	SHIPTM(B,B,3)	SHIP(NOSHIP,7)
SHIPSC(NOSHP,3)	SHOPEO(NOPEOP,5)	SHIPTO(B,20,2)
SHOPAG(NOAGE)	SHORT(NOPART)	SHOPRQ(30,M,T)
SHOPS(28,30,B)	SHPT(B,B,3)	SHORTS(50,2)
SHPORD(50,T,B)	SLOWDN(MVDC,10)	SHPTSK(3,NOTASK,25,T)
SICK(NOPEOP,4)	SORTHR(24,B)	SORCAP(T,B)
SORDEF(16,3,M,T,B)	SQSOR(B)	SRFRAC(B,2)
SQDEL(B,M)	SPARE(2,M,T,B)	STAFF(NOPEOP,2)
START(7)	STOP(7)	SURGEN(12,B)
SVEFLT(12,5)	TAXIWT(7,B)	TCONF(M,M,T)
TEMPF(50,4)	THDATA(4,3)	TOCIRF(NOPART,2)
TOHOSP(5,NOHOSP)	TOTALS(NOPART,B,3)	TOTHOL(5)
TOTREP(B,4)	TPART(EXTPRT,3,B)	TRAFIC(6,22,B)
TRAP(NOTRAP,B)	TRAPRQ(2,3,T)	TRAY(NOPART)
TRAYS(NOTRAY)	TRAYST(NOTRAY,2,B)	TRYFLY(6,T,B)
TSKALT(NOTSKA,5)	TSKCRT(99,5)	TSKPR(25,T,3)
TSKRQT(NOTSK,16)	VALUES(5,10)	VARPK(6,B)
UTIL(12,75,B)	WORST(10,B)	WR(500)
WID(5)	WXDATA(WXDAYS,2,B)	XMIT(4,B)
WRDATA(20,2,B)	XSORHR(24,B)	XSTAT(10,30,B)
XN(500)	YH(500,2)	YN(500)
XXSTAT(10,30)		ZTASKS(5,T,B)
ZPRTRQ(NOPART)		

DYNAMIC HEAPS AND QUEUES

ATC(4,NOATC)	BACKLG(5,LLQ)	BUILDQ(LBQ,17)
CEJOBQ(LTHCEQ,15)	CHANGE(NOCHG,5)	COOLER(LCOOLQ,7)
DEFTSK(LDT,4)	FLTRQT(LFQ,10)	INTTSK(LIQ,13)
LIMBO(NLIMBO,6)	NORQ(LNOR,3)	PRDFLT(MAXPER,5)
REJOIN(NJOINT,2)	REPQ(LRQ,18)	RESUPP(LGQ,5)
RQDTSK(LNT,2)	SHIPQ(NOPKG,3)	TASKQ(LTQ,22)
	WAITSK(LWQ,13)	

+ NOPRT MUST INCLUDE ALL SIMPLE PARTS AND LRUs.

XIX. DATA ENTRY

The data requirements for TSAR are substantial, and it is mandatory that the user observe the specifications described here. Even though TSAR checks input data for a considerable number of errors, many possibilities for error remain and great care should be exercised with data entry. Careful adherence to these data entry form specifications and use of the checklist in Sec. XXII should minimize the difficulties in developing TSAR data bases.

Data entry is accomplished using the 50 basic card formats and some special control cards, which are illustrated in this section. With few exceptions (to be described), all cards are read with the same format (I2,I3,15I5) and all data must be right-adjusted. The number of the Card Type (denoted as "CT" throughout the *User's Manual*) appears in the first two-column field. The second field (cols. 3–5) is occasionally referred to as the "J" field. In certain instances the number in the "J" field designates a subordinate card format (e.g., CT2/1 in Fig. 2, and CT23/72 in Fig. 10); in other cases the data in the "J" field are input data. Although there are only a few constraints (see Sec. XX) on the actual order in which the cards are arranged, data organization will generally be simplified and fewer errors introduced if the various card types are entered in numerical order.

The proper organization of a card deck of TSAR input data is illustrated in Fig. 1. The rules for entering data on all of the card types will be explained in full detail below. Several special control cards are needed in addition to the formatted input data cards. The first input card controls which of the numbered input cards are to be echoed as a part of the printed record of the job. That card is followed by the Primary Control Cards, CT1 through CT4, and whatever comment cards the user has added after CT1; these cards define the user's selection of the primary control data, as will be described shortly. Descriptions of the various kinds of jobs, the quantities of resources available at each of the airbases, specifications for the transportation and communications systems, etc., are entered next using CT5 through CT49. Special comment cards, with a 'C' in column 1, may be entered along with these input data cards at any point where a numbered card type could appear; these card images are reproduced in the output. The end of this large set of input cards is designated with a CT99; following that is another special card that

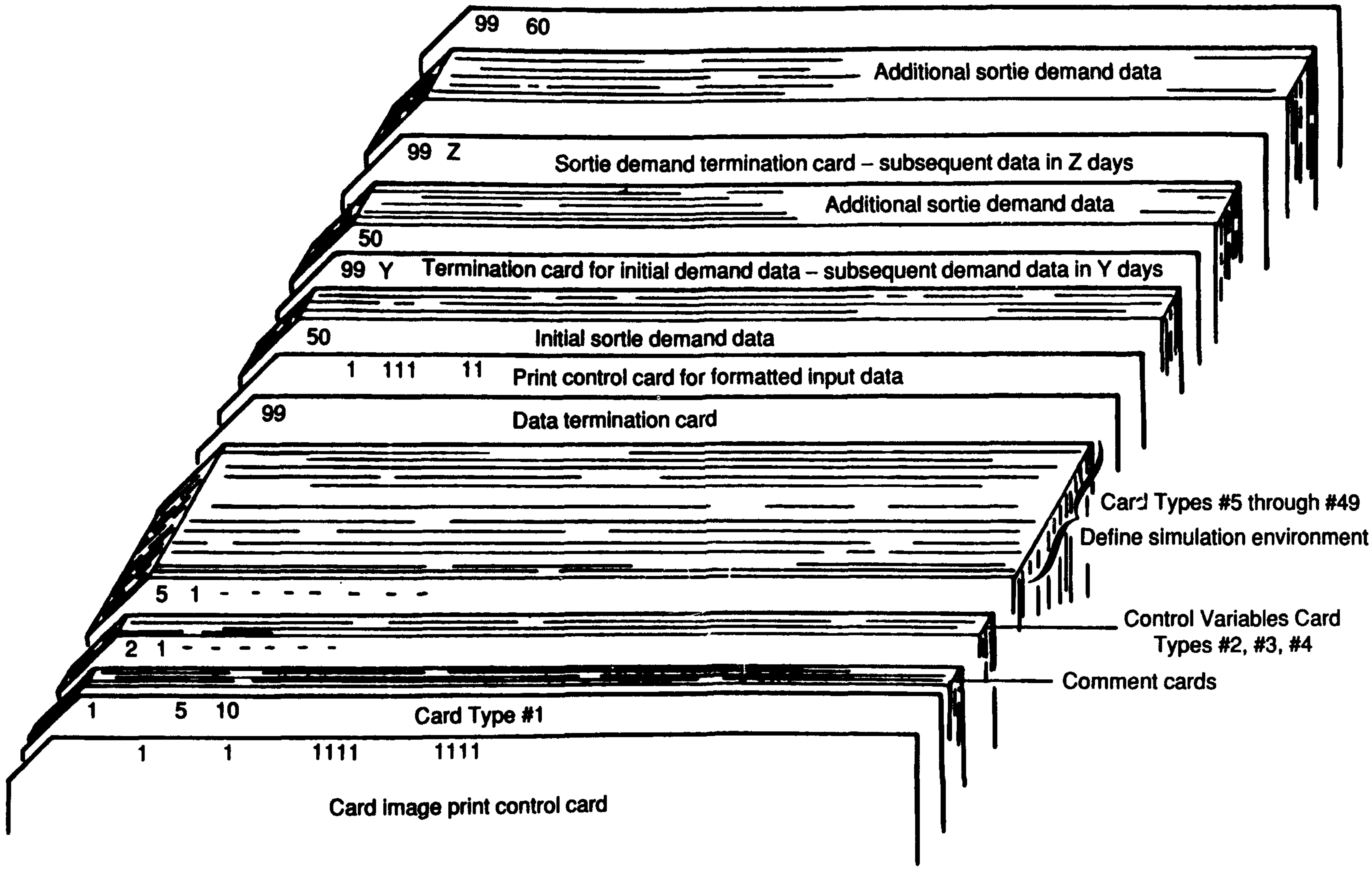


Fig. 1—Organization of TSAR input data card images

controls which, if any, of the initialized contents of the data storage arrays are to be listed in the printed record of the job.

The sortie demand data (CT50 cards) and any transportation schedule changes (CT60 cards) conclude the input data deck. These cards may be arranged in several groups that are to be read at different times during the simulation; the last of the first group of such cards is denoted by another CT99 card that specifies (in the "J" field) the day of the simulation when the next group of sortie demand data are to be read (day Y in the illustration). As noted in Fig. 1, each subsequent group of sortie demand data cards is also terminated with a CT99 card and each of these cards must specify how many more simulated days are to elapse before additional sortie demand data should be input.

Most data for TSAR are intended to be stored as half-words (two-byte integers), and many of the half-words are packed with 2, 3, 4, or 5 pieces of data. Because TSAR was designed to be compatible with a 32-bit-word machine (e.g., IBM 370/3032), the largest integer that may be stored in a half-word is $2^{15}-1$. The number 32750 is occasionally used in the code to denote "infinity" and no larger number may be entered in many of the five-column fields (when 50,000 units of fuel were inadvertently provided an airbase in an early test run, the quantity was recorded as negative, and all sorties were grounded). Input data are checked for any violation of this constraint.

One consequence of these data storage features is that since time in the simulation is divided into three-minute increments (referred to as TTU—TSAR time units) the nominal maximum length of time that can be simulated per trial is 65 days; to generate a single history of greater length, it is necessary to use the EXTEND feature (see CT1).

The Card Type descriptions that follow contain (a) the entry form formats, (b) a description of the data requirements, and (c) comments on the occasional nonstandard formats. Data are sometimes packed on input—i.e., two or more data items are sometimes read in the same five-column field.

Although TSAR will be compatible with machines that use more than 32 bits for a word, it will not function properly on a machine that uses a shorter word. For those installations where half-words (2-byte integers) are not available, data storage requirements will be nearly doubled, but no difficulties should be encountered with the "packed" data.

As illustrated in Sec. XVII, the TSAR simulation includes several classes of resources, each of which may include many different types. Within each class, each type

must be represented by a unique number. TSAR is also concerned with other classes of entities, such as on-equipment maintenance tasks, part repair tasks, and airfield damage repair tasks, which also must be assigned unique numbers within each class. (That is, "on-equipment maintenance tasks" is an entity class; each specific task [defined on CT5] must be assigned a unique number.) These various type numbers designate the column of an array in which the data regarding that entity are stored. A sample dictionary of such user-selected designations is presented in Sec. XX. To define these designators the user must:

- Identify each class type that is involved in his problem with a type number,
- Assure that that type number is no greater than the size of the storage array for that class of information and that only one type of that class has that number,
- Maintain lists (dictionaries) of such definitions, external to the program, to avoid confusion and minimize errors,
- Assure the accuracy of all cross-references within the input data that involve these type numbers.

SPECIAL AIDS FOR DEVELOPING COMPLEX TSAR DATA BASES

Development of TSAR data bases for simulations that involve several aircraft types and many airbases will require manipulation of large numbers of card images. Typically, the various card types that are used to introduce aircraft characteristics are developed separately for each type of aircraft, and the several card types that describe the resources and facilities for an airbase are also developed separately. When one wishes to combine two or more aircraft types and/or two or more airbase descriptions, it is normally required to modify a large number of entries that define the types of tasks, repairs, personnel, equipment, parts, etc., in order that the same number is not assigned to two entity types that are actually different. Similarly, when the descriptions for several bases must be combined, the base number must be changed on many cards so that each base has a unique number.

The auxiliary program RENUMBER (App. F, Vol. III) permits the user to specify a fixed increment to be added to each task type, each personnel type, each equipment

type, each part type, etc. When the card images used to define an aircraft type[1] are processed with this program, the needed changes are made in all appropriate locations.

To simplify the task of combining the data for several bases into a single data base, the user can store the several card types that describe each base as a separate data set[2], and then use the CT17/88 cards to (1) recall the dataset for each base, (2) enter the appropriate base number in all required locations, and (3) integrate these data with the other input data. The user specifies the device where the data are stored and the base number that is to be assigned with the CT17/88 card, and subroutine BEDOWN reads the data and modifies the base number in all required locations. The only requirements are that the CT17/88 cards *must* be entered *after* the Primary Control Cards (CT1 through CT4) and *before* the CT99 card that precedes the CT50 cards, and *must* be organized so that the base data are entered for the bases in numerical order; this last requirement is the same as that imposed for the normal CT17 cards, and for the CT20 and CT41 cards that specify the numbers and assignments for the aircraft on the airbases.

TSAR PRIMARY CONTROL DATA

The Print Control Card must be the first card in the TSAR input deck, immediately preceding the Primary Control Cards. When a 1 is entered in column N of the Print Control Card, each Card Type #N will be echoed at the beginning of the output. The input data on those Card Types with a null or zero in the corresponding column will not be listed. To limit the length of the input data listing, there are two exceptions to these rules: (1) If a 2 is entered into column 17 only the more basic airbase data on CT17/1, CT17/2, and CT17/3 are listed, and (2) if a 2 is entered in column 23 of the Print Control Card, only the CT23/70, CT23/72, CT23/74, and CT23/76 cards will be listed.

The Primary Control Cards, CT1 through CT4, shown in Figs. 2, 3, 4, and 5, provide for entry of key TSAR control variables. These cards *must* precede all other card types and *must be entered in numerical order*. All data *must* be right-adjusted. The many control variables that the user sets with CT1 through CT4 either define operating

[1]These include CT5 through CT15, CT21 through CT23, CT28, CT29, CT34, CT35, CT38, CT45, and CT46.

[2]These include CT17, CT20 through CT26, CT29, CT30, and CT36 through CT43, except that the CT20/66, CT2x/88, CT22/66, CT23/66, CT23/88, and CT27 cards as well as the CONUS shipments (CT31), intratheater transportation schedules (CT32), NRTS locations (CT34), and air attack data (CT40) may *not* be included.

conditions for the simulation, activate (or deactivate) TSAR's optional features, or indicate the user's choice among optional operating modes.

Two special convenience features may be invoked with CT1 and CT2/1. If the user desires to have his output headed by N lines of descriptive material, the number N is entered in columns 3–5 on CT1, and N card images are then mandatory before CT2/1 is read; there are no restrictions as to the format for these descriptive materials.

The first control variable on CT2/1 is TEST. A null entry is appropriate for normal operation, but various intermediate debugging data may be obtained by initializing this variable. For positive entries between 1 and 30, an ever-increasing amount of such data will be printed for all trials. An entry of −1 will limit debugging output to one or up to seven specific periods of simulated time during a specific trial. When TEST is set to −1, a single card image must immediately follow CT2/1, which specifies the trial, the time intervals, and the value for TEST during those time intervals. This card is read as I3, I2, 14I5; the order of entry data is TTRIAL, TEST, START(1), STOP(1), ..., START(7), STOP(7). If the trial number (TTRIAL) is not specified, the output will occur during the first trial. The times are to be entered in TSAR time units (i.e., 3-minute time intervals); one to seven time intervals may be specified and the intervals must be entered in the order of their occurrence.

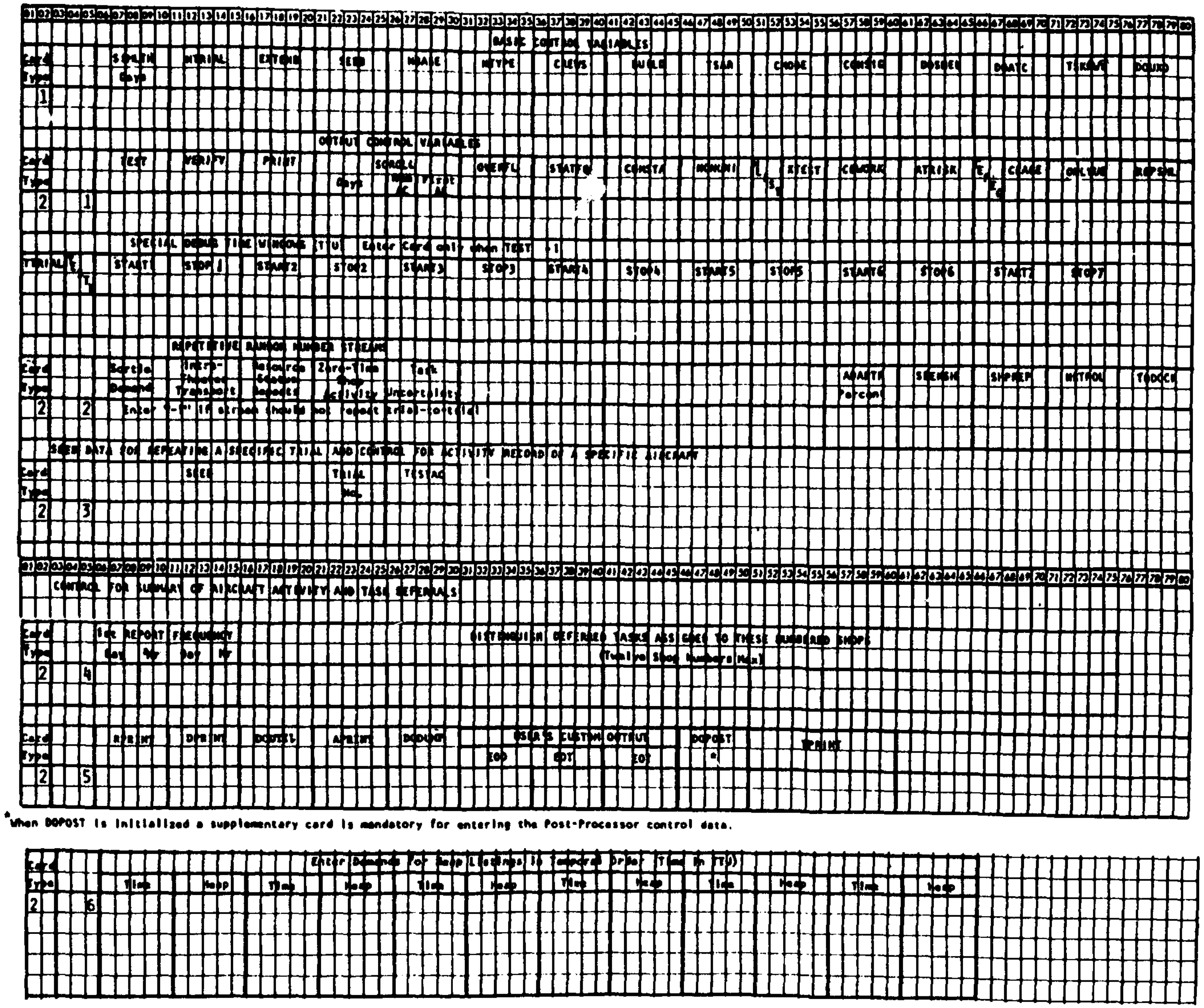


Fig. 2—TSAR control variables

Card Type #1

If J is not zero, J comment cards must follow this card.

SIMLTH	Number of days of the period to be simulated.
NTRIAL	Number of repetitions (i.e., trials) of the simulation.
EXTEND	If = 1, an NTRIAL simulation produces a single history NTRIAL × SIMLTH days in duration. This option may not be used for shipments or attacks after the SIMLTH day.
SEED	If set equal to a nonnegative odd integer, the operating system selects a reproducible value for the SEED of the random-number generator; if set to zero the SEED is selected by a random process.
NBASE	Number of bases that will launch or recover aircraft (must be less than or equal to MAXB); this includes all combat bases (see OPSBSE on CT3/1), the emergency recovery base (EMERG on CT3/2), if any, and any rear maintenance bases designated on CT15/2.
NTYPE	Number of aircraft types to be used in the simulation (must be less than or equal to MAXT).
CREWS	Air crews are simulated when = 1, not simulated when = 0.
BUILD	Switch; when unity, the munitions assembly features are activated.
TSAR	When = 1, resources are managed centrally; when = 2, the highest numbered base will act as a centralized intermediate repair facility that does not operate aircraft—i.e., no aircraft "belong" to this base. If TSAR is 3, the theater repair facility does not normally repair parts for the operating bases but only handles such work when the capabilities at a base break down.
CMODE	When not zero, defines the mode of operation for theater resource management. CMODE = 100 × CTHEA + 10 × CCIRF + SHOPRY (see Sec. XI., Vol. I).
CONSIG	When = 0, any parts that are shipped to the theater to replace condemned parts and LRUs that were NRTSed to CONUS are consigned to the base of origin on return; when = 1, all parts are consigned to the theater manager for distribution.
DOSHEL	When > 0, aircraft are removed from shelters when they are launched and reassigned an aircraft shelter, if available, upon landing. When DOSHEL is 1, aircraft are assigned a parking location on a ramp if no shelter is available; when DOSHEL is 2, aircraft may not recover, or be transferred, unless a space is available in an accessible, undamaged shelter, except at a base that never had shelters; when DOSHEL is 3, aircraft may not land, or be transferred, unless an accessible space is available, or unless it is the EMERG base or a rear maintenance base. If DOSHEL is 0, and a base has aircraft shelters, aircraft are in the

same shelter that is assigned at time zero, whenever that aircraft is not flying, independent of damage or accessibility (should not be used when attacks may kill shelters or disrupt the taxiways).

DOATC	When > 1, a queue of runway activities is maintained for each airbase, and time slots will be scheduled for the take-off and landing of each flight; if times are not available because of each base's unique air traffic control constraints, the flight is canceled. If = 2, the available aircraft are reduced (down to the minimum flight size) in order to meet the tasking and to avoid a flight cancellation. If 10 is added to either 1 or 2, the air traffic control constraints may be expressed uniquely for the (1) main runway, (2) the main taxiway, and (3) any or all secondary taxiways (CT17/11).
TSKRWY	Controls logic used for selecting the location for the minimum operating surface (MOS). When = 0, the location is selected that has the fewest craters, and ties are broken by the location that has the fewest manhours required to clear mines and unexploded ordnances (UXO); when = 1, the location selected for the MOS is that with the smallest total number of manhours required to clear the mines and UXO and to repair the craters (see Sec. VIII, Vol. I).
DOUXO	When = 1, the special UXO detonation logic is activated.

Card Type #2/1

TEST	Controls internal debugging features. If > 0, diagnostic messages are printed for the entire simulation; if – 1, a special card must follow, defining the time intervals for the debug output.
VERIFY	Controls input data testing features. If ≥ 0, a variety of warning messages are listed; if ≥ 2, operation is terminated after initialization. Subroutine TESTER must be consulted for interpretation of most of the error messages generated in that subroutine. Setting VERIFY to zero before a data base is thoroughly scrubbed is dangerous because fewer data checks are carried out.
PRINT	Value controls content of simulation output (see Sec. XV, Vol. I).
SCROLL	Provides aircraft activity reports for SCROLL days for the number of aircraft specified (maximum of NSCROL), starting with the specified aircraft.
OVERFL	Value controls simulation behavior if the dimensions of the arrays used to store internally generated data are exceeded: When OVERFL = 0, simulation stops; = 1, overflow noted and tallied; = 2, overflow noted for first entry and tallied; = 3, overflow tallied. An OVERFL value other than 0 must be used with caution because program behavior can become extremely erratic when certain types of records are discarded. In any event, execution is terminated automatically (and a message printed) at the end of any day if the cumulative number of discarded records is 20 or more.
STATFQ	The frequency, in days, with which the summary data regarding the average length of time for tasks, and the causes and lengths of the aircraft delays, are printed. If STATFQ = 0, these data are not collected or printed.
CUMSTA	Controls the cumulation of task and delay time data; when 0, data are cumulated separately for each trial; when 1, data are cumulated across all trials.
NONUNI	When unity, resource losses are determined by a sample from the binomial distribution; if zero, losses are determined on a straight percentage, or expected value basis, as the closest integer number.
MLIST	When zero, the output will include the cumulative fraction of aircraft readied for flight (excluding preflight tasks) in 2, 4, 6, and 8 hours; when unity, the output will include the cumulative fraction of aircraft readied for flight in each half-hour period from 30 minutes to 24 hours.

XTEST	If > 0 and VERIFY = 2, TEST is set to XTEST for the last portion of the initialization process carried out by subroutine TRIALS.
CEWORK	When = 1, civil engineering resources are allocated to repair damage from airbase attacks; when = 0, no attack damage is repaired.
ATRISK	When a shop facility, or all elements of a distributed shop, are damaged at the time of a subsequent attack, the resources assigned to that shop are assumed to have been relocated and to be invulnerable when ATRISK is zero; when ATRISK = 1, the damage is assessed as though the resources are distributed as in the undamaged case.
CEPEO	The maximum number of types of civil engineering personnel; limit = 25.
CEAGE	The maximum number of types of civil engineering equipment; limit = 25.
ONLYUE	When = 1, TSARINA generated equipment loss rates are applied only to unassigned equipments; when = 0, those loss rates are applied to all equipment.
REPSHL	When = 1, the logic for repairing aircraft shelters damaged in air attacks is activated. If TSARINA reports shelter damage, and REPSHL = 0, those shelters are effectively destroyed.

SPECIAL DEBUG TIME WINDOWS

When the value of TEST entered on CT2/1 is −1, a special card must be entered immediately thereafter to define when the program debugging features are to be actuated. Entries on this special card include the number of the trial during which the debug outputs are to be listed, the value for TEST, and the beginning and end of up to seven time intervals during which the debug data are to be listed; all times will be expressed in TTUs (3-minute time increments). The format is I3,I2,14I5.

Card Type #2/2

The random events in TSAR are determined by random sampling from discrete probability distributions. The a ·ual values for the random variables are obtained by drawing a random number from the uniform distribution on the interval (0,1) and transforming it so that it has the required distribution. In general, the random numbers for all the random events and all trials are drawn from a single random number stream that is fixed by the program. However, TSAR provides ten additional "hard wired" random number streams that are used for certain specified classes of random events and that are repeated from trial to trial (i.e., the values for the random events are the same from trial to trial).

The N*th* additional random number stream can be "disengaged" by placing a –1 in the N*th* field of CT2/2. The random numbers for the random events associated with the N*th* stream are then drawn from the single common random number stream and hence are not repeated from trial to trial.

At this time, only five of the random number streams are used. The first random number stream (cols. 6–10) is used in the generation of TSAR's aircraft sortie demands; the second is used in selecting the intratheater transportation schedules; the third is used in generating resource status reports used internally for resource management; the fourth is used for selecting the zero-time shop activity controlled by CT42; and the fifth is used in generating "actual" task probabilities for unscheduled maintenance when UNCER is not zero. Random streams six (cols. 31–35) through ten (cols. 51–55) are available for new applications.

AUXILIARY CONTROL VARIABLES

ADAPTR	NRTS (Not Reparable This Station) policy for RR parts is changed when there are fewer line replaceable units (LRUs) than ADAPTR percent of the initial LRU stocks; they are shipped to a lateral resupply base (defined by CT23/74) rather than to the nominal NRTS destination if the NRTS rate at that base is lower than at the base where the reparable was generated.
SEEKSH	When unity, another in-theater shop is sought for parts repair, when the nominal shop (or all locations of a distributed shop) is closed by damage.
SHPREP	When not zero, all parts repaired at an operating base are shipped to the base that is selected with the SEND logic in the CONTRL subroutine (see Sec. XI, Vol. I), when (On-base NMCS Aircraft – Required Parts) is greater than, or equal to, SHPREP.

NRTPOL	If unity, an LRU that requires an SRU that is unavailable, and for which the nominal stock level is zero, is NRTSed.
TODOCK	If unity, parts that are normally NRTSed to another base, but can't be because no shipment schedule exists, are held for later lateral repair rather than being sent to CONUS, in the expectation that shipments will be reinitiated.

Card Type #2/3

This special Card Type is only used during debugging operations; it permits the user (1) to repeat a specific trial of a prior run by entering the value of the seed for the random number generator that was printed at the beginning of that trial, or (2) to request a report on all activities of a specific aircraft. The value of the seed should be right-adjusted in columns 6–20. (If the seed is a negative ten-digit number, enter –1 in columns 9 and 10.) To access data that has been stored for a specific trial (e.g., runway hit data), the number of the trial should be entered in columns 21–25, and NTRIAL set to the same number. If the problem to be examined involves air attacks, it is necessary to place the CT40 cards for the trial in question in the input deck; they must be concluded with a card with 40999 in columns 1–5 so that the appropriate data will be selected from the "Hit Data" on Device 18.

When the number of a specific aircraft is entered in columns 26–30 of CT2/3, the beginning and end of each activity on that aircraft will be listed in the output.

Card Type #2/4

This card, in conjunction with the variable DPRINT (see CT2/5), can be used to obtain periodic data that summarize current aircraft status and that define how deferred aircraft tasks are distributed among the aircraft at each airbase. The day and hour for the first report should be entered in the first data field (cols. 6–10) and the period between subsequent reports should be entered in the second data field (also in days and hours). If the user wishes to distinguish between all deferred tasks and those that "belong" to some subset of the shops, the shop numbers for that special set of shops should be entered in fields 3–14 (i.e., a maximum of 12 "critical" shops). Only the summary of aircraft status is presented for DPRINT ≤ 1; additional data on aircraft status and the distribution of deferred tasks are presented for DPRINT = 2, 3, and 4.

Card Type #2/5

This card provides for the control of additional output options.

RPRINT — Controls intermediate output that defines the status of the runway/taxiway clearance tasks: If ≥ 1, lists the numbers of UXO, mines, and craters that must be cleared to open the MOS, extended MOS, or entire runway, and the percentage of the aircraft shelters that can access the MOS. If ≥ 2, indicates when the MOS, extended MOS, and entire runway are cleared, when the individual taxiway segments are cleared, and the percentage of shelters that can now access the MOS. If ≥ 3, indicates casualties and equipment losses due to UXO explosions. If ≥ 4, lists the start time, stop time, and interrupt time for each runway and taxiway clearance task, along with key task data.

DPRINT — Controls special output that summarizes current aircraft status and provides information on deferred aircraft tasks; only current aircraft status is summarized when DPRINT = 1; when ≥ 2, aircraft status by aircraft type and a summary of deferred tasks are also listed. When ≥ 3, the mission assignments and aircraft status (i.e., ACN(-,12)) are listed for each aircraft type; the numbers of tasks and numbers of critical tasks also are listed for each aircraft; when ≥ 4, the aircraft number and type are listed for each aircraft. Detailed information on ongoing, waiting, and interrupted tasks for individual aircraft can also be listed; when DPRINT = 1000, these data are provided for aircraft at all bases; for DPRINT = 100 + BASE, data are provided for only one base.

DOUTIL — Controls special personnel utilization record. When > 0, data are collected on personnel activity, and the cumulative average availability of each type of personnel is listed for each odd-numbered hour every DOUTIL days. (If DOUTIL is negative, these data are only collected and printed for operational bases; i.e., for OPSBSE bases.)

Detailed manhours are also maintained when DOUTIL is initialized and are listed at the end of each trial (if PRINT ≥ 8) and at the end of all trials. For organizations that assign personnel to separate squadrons, the manhours for the same AFSC in the different aircraft squadrons are combined.

APRINT — Controls certain special output at attack time; if ≥ 2, the number of casualties of each personnel type are printed at attack time; if ≥ 3, the numbers of those that were hospitalized due to conventional and chemical effects are also listed for each personnel type.

DODUMP — Controls disk storage of event data for subsequent analysis with auxiliary postprocessor programs. Whenever DODUMP > 0, each aircraft takeoff and landing is logged; the other data retained on Device 19 are determined by the value of DODUMP as follows:

DODUMP	Types of Records Stored		
1	T	R	B
2	T	R	
3	T	B	
4	T		
5	B		
6	R	B	
7	R		

where T = on-equipment tasks,
R = backshop jobs, including equipment repairs, and
B = weapons assembly tasks,.

When one or another of these numbers is entered for DODUMP, a record is stored of the base, task, aircraft (where applicable), start and stop times, and the personnel and equipment assigned.

When a "10" is added to any of these numbers, data are also recorded at the end of each period of waiting, along with the resource type whose shortage caused the delay.

USERS CUSTOMIZED OUTPUT — These three control variables control the number of data elements that will be listed from the two data collection arrays that are provided for special output data designated by the user. The first data array provides for up to 20 data elements that are cumulated each day, throughout each trial, and for all trials; the second data array provides for up to 20 data elements that will be cumulated throughout each trial and for all trials. The first of these three control variables designates how many of the daily cumulations are to be listed at the end of each day; the second designates how many of the first data array cumulations are to be listed at the end of each trial; and the third designates how many of the data elements in the second array are to be listed at the end of each trial. The multitrial averages are listed for all data elements (see also Sec. XV.3, Vol. I).

DOPOST — Activates the postprocessor provisions. When utilized, a special supplementary card image is *mandatory* immediately following CT2/5. The 80 columns on this supplementary card image provide for control of up to 80 distinct records that can be written onto disk for subsequent analysis and graphic representation. The records currently available for postprocessing are discussed in Sec. XV.4. A "1" or "2" entered in the N*th* column on the supplementary card directs that the N*th* record be stored on disk; a "2" will, in many instances, suppress the normal listing in TSAR's printed output.

TPRINT — Controls special commodity shipment arrival reports. Reports of the arrival from CONUS of commodities of Class i are printed when a "1" or "3" is entered in Column (50 + i); reports for intratheater shipments

are listed when a "2" or "3" is entered. Each report specifies the number, type, and class of commodity as well as the time and base at which they were received; the base that sent the commodity is also listed for intratheater shipments.

Card Type #2/6

Another TSAR debugging feature permits the user to list the contents of specific dynamic heaps and queues at prescribed times during the simulation. This feature is controlled with the CT2/6 card. Up to 25 pairs of times and array designations may be entered for any single run; times (in TTU) are entered in fields 1, 3, 5, . . ., 11, and the corresponding array designations are entered in fields 2, 4, 6, . . . , 12, respectively. The times entered must be in ascending order. The (quite extensive) listings that are produced will be the first action taken at the specified time (i.e., before the other activities scheduled at that moment); they will only be printed during the first trial of a multitrial run, or for the trial specified on the CT2/1 supplementary card (when used). If "1000" is added to certain array designators, only enough rows of the array are printed to include the heap pointer system; if "10000" is added to an array designator, the run will be terminated after that array is listed.

The numerical designators for the 23 arrays currently available for listing using CT2/6 are:

1 ACN*	7 COOLER*	12 NORQ	18 SHIPQ
2 ATC	8 DEFTSK	13 PILOT	19 TASKQ*
3 BACKLG	9 FLTRQT	14 REPQ*	20 TOHOSP*
4 BUILDQ*	10 INTTSK*	15 RESUPP	21 WAITSK*
5 CEJOBQ*	11 LIMBO	16 RQDTSK	22 REJOIN
6 CHANGE*		17 SHIP	23 EXPLOD

* The output listing for these arrays may be shorted by adding "1000" to the number designating the array.

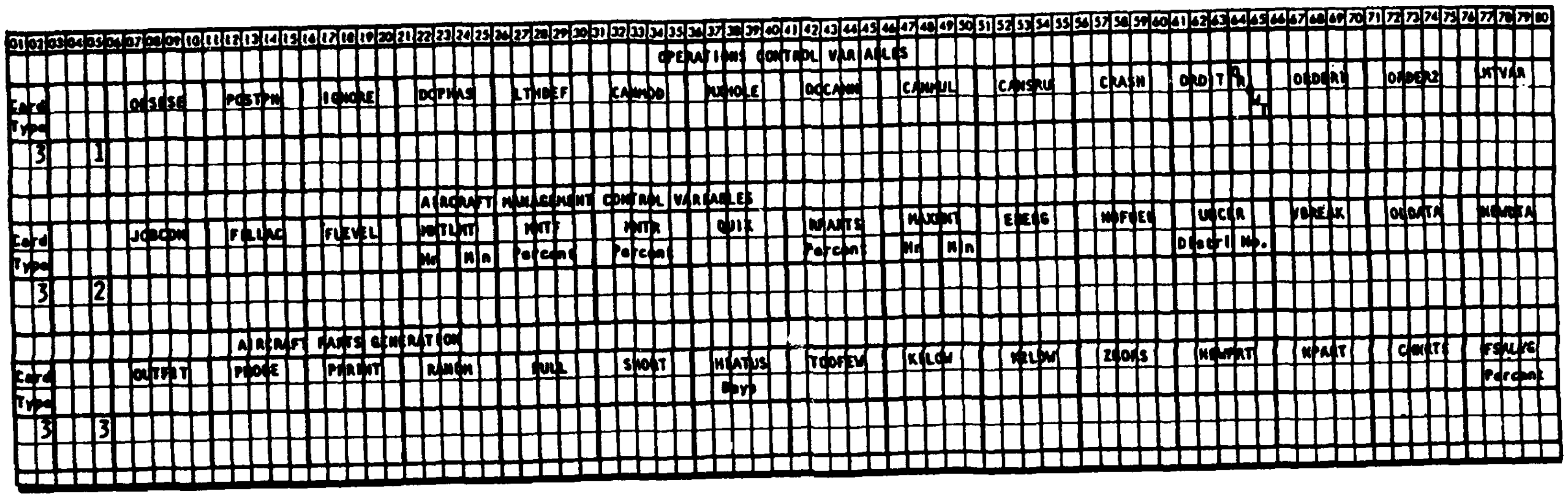


Fig. 3—TSAR policy control variables

Card Type #3/1

OPSBSE	Number of airbases that may launch combat sorties (these must be the lowest numbered bases in the list of bases); excludes rear maintenance bases, the emergency recovery base (EMERG on CT3/2), and a centralized intermediate repair facility, if any.
POSTPN	If = 0, all unscheduled maintenance tasks must be accomplished before next flight; if = 1, tasks will be deferred (postponed) that are not critical for next mission.
IGNORE	If initialized to unity, all jobs that may be deferred indefinitely for all missions are ignored.
DOPHAS	If not zero, phased maintenance features are activated. If = 1, phase maintenance is performed at night as required; if = 2, phase maintenance is ignored until DOPHAS is reset to "1" with the appropriate CT49 card.
LTHDEF	Unscheduled maintenance tasks whose criticality is greater than 66 may be deferred ("back-pocketed") for a maximum of LTHDEF sorties.
CANMOD	Cannibalization mode: for conditions that apply when > 0 see Sec. IV, Vol. I; if zero, parts cannibalization is not permitted.
MXHOLE	The maximum number of "holes" that may be created on a single aircraft by cannibalization (default = 10000).
DOCANN	When DOCANN is greater than zero, parts for which the CANNTM (see CT35/1) is less than –1 may be cannibalized if the number of aircraft that require the part at the base is greater than DOCANN.
CANMUL	The task time for the task segment that specifies a part, is equal to CANMUL/100 times the nominal task time, plus CDELAY (CT4/1), when the part is obtained by cannibalization. The default value for CANMUL is 150. This time is replaced by the CANNTM when a specific value is specified with a CT35/1 card.
CANSRU	If not zero, SRUs may be removed from one LRU to repair another LRU, if the needed SRU is not in stock and aircraft are NMCS for that LRU. At a CIRF, an LRU will be similarly salvaged, if the total NMCS count in the theater is greater than or equal to the value of CANSRU.
CRASH	When runways are closed at all operating bases (and at any emergency base), recovering aircraft will be lost if this variable is initialized to unity; if not initialized, the sortie length is artificially extended such that the aircraft will land after the runway at the planned recovery base has been opened.

ORDIT — Interrupted tasks and repairs are prioritized when ORDIT = 1; FIFO if 0. See Secs. V, VI, and XI, Vol. I, for discussions of priority schemes.

ORDWT — Waiting tasks and repairs are prioritized when ORDWT = 1; FIFO if 0. See Sec.s V, VI, and XI, Vol. I, for discussions of priority schemes.

ORDER1 — Threshold controlling theater response to parts shortages; responds only if (Enroute Parts + On-base Reparables - Required Parts) is less than ORDER1. Response is increasingly restricted for ever-lower values of ORDER1.

ORDER2 — Threshold controlling an operating base's recourse to lateral resupply; seeks lateral resupply only if (On-base Reparables – Required Parts) is less than ORDER2. (Reparables are assessed only if the shop is open and functioning.)

LMTVAR — Control for a feature that may be used to regularize combat attrition and battle damage in order to limit the variance in sorties flown; if 1, combat attrition is regularized; if 2, combat attrition and battle damage both are regularized; and if 3, combat attrition, battle damage, and irreparable battle damage are all regularized by choosing aircraft periodically for losses and damage rather than at random.

Card Type #3/2

These entries jointly control TSAR's mechanisms for replacing lost and heavily damaged aircraft and for transferring and/or augmenting aircraft with extended maintenance requirements.

JOBCON — Controls whether rear-maintenance-base logic is activated, and defines which jobs are to be done when an aircraft is sent to a rear maintenance base:

If = 1, the maintenance scheduled for the rear base includes all mandatory rear-base tasks, all other required tasks, and all mission-dependent deferred tasks that must be done in rear;
If = 2, above plus all mission-dependent deferred tasks;
If = 3, above plus all deferred tasks;
If = 4, aircraft is returned to operating base with all non-rear-base tasks remaining.

FILLAC — Value controls use of filler aircraft:

If = 1, only aircraft losses are replaced from the filler force;
If = 2, aircraft transferred to the rear for battle damage repair are also replaced;
If = 3, any aircraft transferred to the rear is replaced;
If = 4, base aircraft are augmented as for FILLAC = 2, aircraft's on-base battle damage repair time is expected to exceed MAXMNT hours;

If = 5, base aircraft are augmented for any of previous conditions and when an aircraft's unscheduled maintenance is expected to exceed MAXMNT hours.

FLEVEL — The value of FLEVEL affects the decision to augment on-base aircraft and controls the disposition of aircraft repaired at a rear base and aircraft that are transferred from the Continental United States (CONUS) to the filler pool. To requisition an augmented aircraft, or to return aircraft from the rear, the on-base aircraft must satisfy the condition noted below:

If = 0, number of aircraft less than the number of assigned aircraft;
If = 1, number of undamaged aircraft less than the number of assigned aircraft;
If = 2, number of aircraft less than the base's shelter capacity;
If = 3, number of undamaged aircraft less than the base's shelter capacity.

When these conditions are not met, or if they are overruled when DOSHEL (CT1) is greater than 1, newly repaired aircraft and aircraft newly arrived from CONUS are consigned to the filler pool.

MNTLMT — Aircraft whose projected ready-to-fly time exceeds MNTLMT hours are transferred to a rear-area base for maintenance, if the time projected to ready the aircraft for a one-way ferry flight is less than the time for the remaining maintenance, and if the constraints imposed by MNTF and MNTR (below) are also satisfied.

MNTF
MNTR — Candidates for transfer to a rear-area base that are projected to require as much as MNTF percent of the time that would be needed at the rear-area base to be readied for the ferry flight will be transferred only if the estimated maintenance time at the rear-area base exceeds MNTR percent of MNTLMT hours.

QUIK — Filler aircraft used to replace combat aircraft that are transferred to the rear for maintenance are launched at the same time the combat aircraft initiates the ferry flight if QUIK is zero; if QUIK is unity, the filler is launched as soon as the combat aircraft has landed and it is decided that it will be ferried to the rear. The time for the ferry flight is entered on CT2077.

RPARTS — When the automatic parts generation feature is used, RPARTS percent of the parts procured for the forward operating bases will be placed at the rear-area maintenance base(s); these are in addition to those that are transferred to the rear because of tasks that must be handled in the rear.

MAXMNT — If maintenance of on-base aircraft is projected to extend beyond MAXMNT hours, the base will be augmented with a filler aircraft if FILLAC is 4 or 5, and an aircraft is available.

EMERG	Number of the emergency recovery base; when specified will be used for aircraft recovery when the runways at all other bases have been closed; this base may not be used for a CIRF.
NOFUEL	If unity, other preflight tasks are prohibited when refueling is being conducted.
UNCER	When initialized with the number of a distribution from the TTIME subroutine, the "actual" unscheduled maintenance task probabilities used in the simulation are determined by selecting a value from that distribution, assuming the mean is the value entered by CT7. A new set of probabilities is chosen for each trial.
VBREAK	If 0 or −1, unscheduled maintenance task probabilities (for each shop and aircraft type) are modified in proportion to the CT18/2 entries. If unity, these probabilities are modified as a function of the achieved sortie rate; see the CT18/2 description for further detail. If set to −1 or +1, the unmodified (CT7) unscheduled maintenance task probabilities are used for estimating the average shop task times, average resource requirements (in BSECAP), and initial parts stocks.
OLDATA	If zero, resource reports for each base are generated from the beginning of the simulation; if 1, these reports are deferred until time "NEWDTA."
NEWDTA	The time at which the base resource reports are to be initiated; only applicable if OLDATA is initialized as 1.

Card Type #3/3

The following control variables control the automatic generation of base parts stocks, when that option is elected. (See Sec. VI, Vol. I, and subroutine IPARTS.)

OUTFIT	Activates the automatic parts stock initialization when > 0; set = 1 if there is no centralized intermediate repair facility (CIRF). With a CIRF there are four procurement logic options corresponding to OUTFIT = 1, 2, 3, and 4; see Sec. VI.1, Vol. I.
PMODE	When unity, parts initialization of WRSKs approximates DO-29; otherwise the Chapter 11 procedures from AFM 67–1 are used.
PPRINT	Controls output summaries of the initial stock levels and the parts pipelines. If set to 1 or 3, all parts are listed for each base; if set to 2 or 4, only parts that are stocked are listed. If 3 or 4, the initial pipeline contents are also listed. If 4 is added to these values, the initial stocks are not listed, only the pipelines. When increased by 10, residual parts levels are listed every STATFQ days with the delay statistics. When negative, the initial listing includes both the generated quantities and the individually specified quantities.

When PPRINT $\geq$ 30, the results of the automatic parts generation computations are organized and listed in the format specified for the basic CT23 cards, and model execution is terminated; the card images that are generated in this way can be used as input data for subsequent cases.

RANDM	When unity, parts shortages and the location of parts in the pipelines are determined with samples from the Poisson approximation of a binomial distribution.
FULL	If unity, all parts are on base, none enroute, at zero time (identified as NOPIPE in Common).
SHORT	Parts shortfalls from "authorized" levels (percent) that result from system-wide shortages.
HIATUS	Delivery of parts in pipeline at the beginning of the simulation are to be delayed HIATUS days.
TOOFEW	If positive, the parts supply system is "critically short" for a certain number of aircraft spare part types, because of insufficient parts system-wide. This number of affected parts equals TOOFEW/1000 times the total number of aircraft spare parts that have been identified. The part numbers that are short, are selected at random. If −1, the probability a part is short is proportional to the cost of the part; thus, the most expensive part has a unity probability of being short.
K1LOW K2LOW	For parts that are "critically short" the actual stock level, as a percentage of the "authorized" level, is selected at random in the range K1LOW to (K1LOW + K2LOW).
ZNORS	If the parts assigned to a base are insufficient to fill the pipeline during initialization, and ZNORS is unity, the required parts are obtained by removing them from an aircraft—i.e., by creating a NMCS condition. If ZNORS is zero, a message noting the shortage is printed.
NEWPRT	If NEWPRT is unity, the parts initialization computations are repeated for each trial.
NPART	The number of the highest numbered LRU or SRU (default = NOPART).
CHNRTS	When spare parts generated by the automatic parts initialization logic are augmented using basic CT23 cards, the NRTS rates during the simulation will be the values in the POLICY array if CHNRTS is zero; if CHNRTS is unity the NRTS value on the CT23 card will be used.
FSALVG	If an aircraft is destroyed by air attack, FSALVG percent of the aircraft's spare parts are assumed to not have been destroyed during the attack, and are salvaged and added to the serviceables.

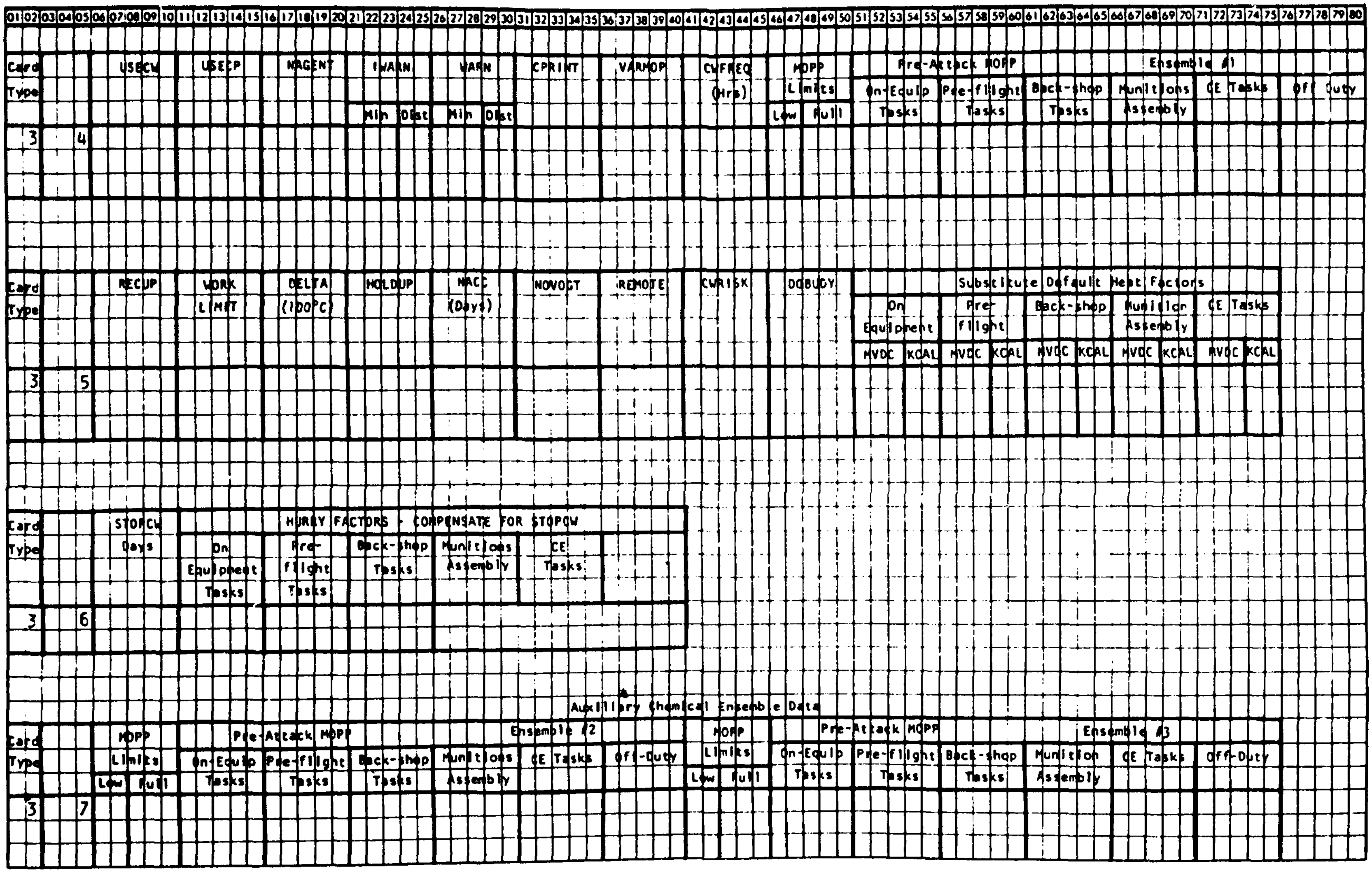


Fig. 4—Chemical warfare control variables

Card Type #3/4

The entries on this card and on CT3/5 provide the basic controls for the TSAR features that permit simulation of chemical warfare effects.

USECW — Activates TSAR's chemical warfare capabilities. Set to 1 to simulate the effects of the personal protection ensembles (MOPPs) on job efficiency and on excess body heat, in the absence of chemical attack. Set to 2 when there are chemical attacks (setting USECW = 2 in the absence of chemical attacks invokes some unnecessary computations).

USECP — Controls the location at which personnel cool off:

- 0 Personnel cool off at the work location.
- 1 Personnel cool off in the specified collective-protection facilities when there is any chemical contamination on base.
- 2 As for 1, except the CP facilities are always used.
- 3,4 As for 1 and 2, respectively, except that the entry queues at the CP portals are simulated.

NAGENT — The number of chemical agents that are involved in the simulation (≤ 3).

IWARN — The number of minutes of warning for the first chemical attack. Negative warning times imply that the chemical weapons have burst that many minutes before the personnel are notified.

WARN — The warning time for chemical attacks subsequent to the first chemical attack.

CPRINT — Controls output of special chemical warfare results:

- If > 1 surface contamination and vapor concentration listed for each monitoring point at the time of a chemical attack, and the current value of MOPP is listed for each facility.
- > 2 residual contamination is listed at the time of each update, and the MOPP is listed for each aircraft shelter and ramp.
- > 3 the MOPP is listed for each taxiway segment.
- > 4 the number of tasks considered in the WORK/REST statistics are listed.
- > 5 a record is printed whenever the Vogt criteria limit task time or determine the required rest.

VARMOP — When = 0, the ensemble that personnel must wear in a particular type of facility is the ensemble (MOPP) that is appropriate for the most highly contaminated facility of that type on base; when = 1, personnel wear that portion of the ensemble that is appropriate for their localized environment.

CWFREQ	The frequency in hours that the chemical contamination at the monitoring points is updated, whenever there is any residual contamination. The contamination is assumed to be constant between updates.
ATTMOP	The two MOPP numbers that define (1) the least portion of ensemble #1 that will be considered, and (2) the full ensemble that will be donned at the time of an attack (see CT3/7 for other ensembles).
Preattack MOPPs	Specifies the MOPP to be worn prior to the first chemical attack by each of five generic task personnel and by off-duty personnel at bases equipped with ensemble type #1; see CT3/7 for bases with other ensembles.

Card Type #3/5

These entries, along with those on CT3/4, provide the key control variables for the simulation of heat and toxic effects of chemical warfare.

RECUP	When = 1, personnel who require hospitalization as a result of heat prostration, toxic effects, or conventional weapon effects are returned to duty after the hospitalization times specified with CT43/5. When = 0, the personnel do not return to duty.
Work Limit	The time that personnel may work in chemical protective clothing is controlled by entering either the maximum allowable collapse probability or the maximum allowable rectal temperature. The limiting rectal temperature is specified in hundredths of degrees Centigrade, in the range 3700 to 3976; permissible values of collapse probability are 0 to 50 percent (50 percent corresponds to 39.76°C).
DELTA	The time that personnel must spend to cool off is the time required for their rectal temperature to fall within DELTA hundredths-of-degrees Centigrade of the equilibrium temperature at their cooling-off location.
HOLDUP	Delays assignment of runway repair personnel when the number required for the basic procedure are not available, and other personnel of the same type will complete cooling off within HOLDUP minutes.
NACC	The number of days personnel have had to become acclimatized to the temperature effects of the chemical ensembles immediately prior to the start of the simulation; temperature rises less rapidly for acclimatized personnel.
NOVOGT	Unless set to 1, the allowable work time and required rest time computations will include checks for excessive perspiration and dehydration (based on Vogt's formulation); see subroutine DEHYDR.
REMOTE	A value of 1 activates a special option for representing a delay in entering collective protection shelters, as described in connection with CT43/6.

CWRISK	The percentage (in tenths) of the chemical protection masks that do not fit properly (for the first chemical attack only).
DOBUDY	When initialized, an uninjured person will be selected to provide buddy care for each casualty; if = 1, persons help only nonfatal casualties; if = 2, all casualties are provided for (see CT44/5).
Heat Factors	The effects of chemical ensembles on heat buildup and work efficiency are based on the heat generated during the task, and on empirical evidence as to how different ensembles (MOPPs) affect task time. The "heat factor" is defined as 100 times the MVDC type (see CT43/3) plus the heat generated doing the task, in tens of kilocalories per hour. These characteristics can be specified for individual tasks when data permit; otherwise all tasks of the same generic type will be assigned a default value. These entries permit the user to change the default heat factors that are "hard wired" in subroutine INPUT (118, 222, 315, 425, and 535, respectively, for the five generic task types). The increase in task time due to the wearing of different chemical protection ensembles is based on test data. The allowable work time and required cooling-off time are determined from the heat generated during the work time.

Card Type #3/6

The CT3/6 card permits the user to discontinue the calculation of chemical effects after a specified time (STOPCW days). This hybrid mode of operation permits the chemical effects to be treated in detail at the beginning of a long scenario, and to then be ignored for the remainder of the scenario, thus substantially reducing the running time for the simulation during the latter period. If, after the specified number of days, no chemical contamination remains on any base and no further attacks are scheduled, USECW is set to zero and other necessary adjustments are made. If some attacks have not yet occurred, or contamination is still present, the use of the detailed chemical treatment is extended for another day. When USECW finally is set to zero, the user also may have specified (in columns 11–35) that the nominal times for the five generic types of tasks are to be increased by specified percentages, as an approximation for the slowdown effects of whatever parts of the chemical ensemble would still be worn. These time factors define the new task times for the remainder of the scenario as a percentage of the nominal task times (much as for the HURRY factor on CT17/2).

Card Type #3/7

This card permits the MOPP limits and the preattack MOPPs to be defined for those airbases equipped with chemical ensemble types #2 and #3. As on CT3/4, the MOPP limits are those numbers that define the least of an ensemble that is worn, and the full ensemble that is donned at the time of an attack.

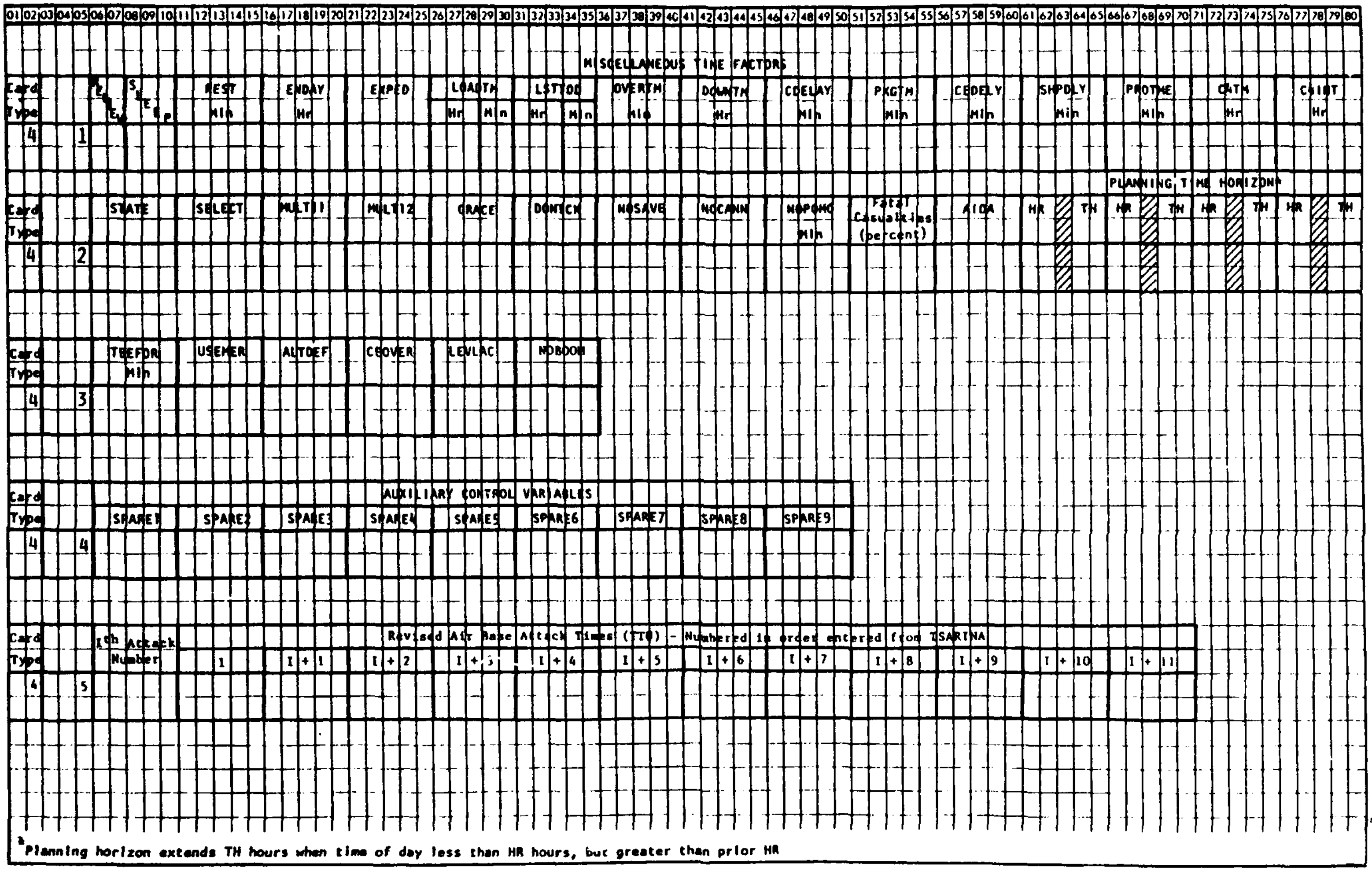


Fig. 5—Miscellaneous TSAR control variables

Card Type #4/1

RELIEV	When = 1, aircrews are assumed to go off duty immediately after their last flight of the day and to be ready for duty SLEEP hours later; otherwise they remain on duty the full shift whether or not they are needed.
SLEEP	Minimum number of off-duty hours between shifts for the aircrews.
REST	Minimum number of minutes between flights for an aircrew.
ENDAY	End of the nominal flying day (hour); after this time preflight tasks (shop #26) are deferred until LOADTM (or LSTTOD) to permit deferred maintenance to be accomplished.
EXPED	When initialized, the parts repair administrative delays (CT47) are reduced to 1/EXPED of the nominal time, if there are no serviceables.
LOADTM	Nominal time to commence preflight preparation for the day (hour-minute).
LSTTOD	Last time for commencing morning preflight tasks (used to limit expected time for deferred tasks) (hour-minute).
OVERTM	Number of minutes of overtime permitted.
DOWNTM	Parts may not be cannibalized from an aircraft with a ready-to-fly time within "DOWNTM" hours.
CDELAY	The task time for the task segment that specifies a part is equal to CDELAY plus CANMUL/100 times the nominal task time, when the part is obtained by cannibalization. This time is replaced by the CANNTM when a specific value is entered with a CT35/1 card.
PKGTM	Number of minutes required to package resources for an intratheater shipment.
CEDELY	Initiation of all reconstruction tasks is delayed by this number of minutes after an airbase attack, to account for the initial delay due to overcoming the disruptive effects of fires, roadway damage, etc. This delay is additive to the delays on CT17/4.
SHPDLY	This delay is introduced to all on- and off-equipment aircraft-related tasks, to account for the disruption following an airbase attack. This delay is additive to the delays on CT17/4.
PROTME	When insufficient aircraft are ready for a scheduled flight, and none can be found in the spare queue or a lower priority alert, an aircraft can be taken from another scheduled flight of the same or lower priority if the flight time is at least PROTME minutes later (default = 30 minutes). (To set PROTME = 0, enter –1.)
C4TM	Time in hours for the initial theater resource review.

C4INT — Time interval in hours between periodic theater resource reviews, subsequent to the initial review.

Card Type #4/2

STATE — If not zero, the state of each base's capability to generate sorties is computed daily (see Sec. XI, Vol. I).

- ≥ 1 — Base-state-data used to select base for diversion.
- ≥ 2 — Base-state-data used to decide when aircraft recover at their parent base (see MULTI1).
- ≥ 3 — Aircraft base assignment reorganized nightly when workloads are disproportionate (see MULTI2).

SELECT — Controls how sorties are assigned when no base is specified and how they are reassigned when runway is closed. When not zero, a daily summary of the assigned sorties is prepared to facilitate selection of bases for sorties.

- = −1 — Sortie demands are not reassigned when runway is closed.
- ≥ 1 — Summary data used when base not specified.
- ≥ 2 — Summary data used for reallocating demands on airbases with closed runways.

MULTI1 — When a base's projected sortie generation capability per assigned aircraft is greater by MULTI1 percent than that of the parent base of an aircraft, that aircraft is retained and not returned to the parent.

MULTI2 — Aircraft reassignment (STATE = 3) activated among bases whose projected sorties per available aircraft differ by more than MULTI2 percent.

GRACE — An aircraft will *not* be counted as a Code 2 or Code 3 aircraft in output reports if each unscheduled maintenance task has a nominal task time less than the GRACE period. This variable only affects the output, not the simulation.

DONTCK — Unless set to 1, the identification numbers on the TSARINA-generated CT40 cards and in the TSARINA "hit data" are compared, and execution is terminated if they do not agree.

NOSAVE — When NOSAVE = 1, records are not stored in the WAITSK array for parts that are not immediately NRTSed and that break after an air attack has closed the shop that would normally process thc repairs, if the projected shop reconstitution time is not earlier than the end of the simulation.

NOCANN — Parts that have a probability (× 1000) of being broken when cannibalized that is greater than NOCANN will not be cannibalized (default = 1000).

NOPOMO	The average additional on-equipment task time that is required at a base operating under 66-1 (maintenance organized at wing level), when the data apply to 66-5 activities (i.e., maintenance organized by squadron). (REDUCE is set to -NOPOMO.)
Fatal Casualties	This percent of the casualties inflicted by air attacks with conventional weapons will be fatalities.
AIDA	Controls the interpretation of base damage data; normally not specified by the user, but generated by TSARINA and entered with the airbase damage data.
HR-TH	The time horizon used with the sortie supply and demand projections may be changed from the default values with these entries; for example, if the entries are 8-12, 24-16 the time horizon would be 12 hours from 0 to 0800 and 16 hours from 0801 until midnight (see Sec. IV, Vol. I).

Card Type #4/3

TBEFOR	The time, in minutes, before ENDAY that dispersed operation base (DOB) aircraft begin to be checked for outstanding overnight maintenance; if aircraft return from combat after this time they recover at their host base, rather than at the DOB, if deferred maintenance is required.
USEMER	When unity, main operating base (MOB) and collocated operating base (COB) aircraft will recover at the EMERG base rather than at a DOB, if all runways are closed at MOBs and COBs; otherwise, they will recover at a DOB.
ALTDEF	When unity, DOB aircraft that should be ferried to their host for deferred maintenance, but can't be because the host's runway is closed, will be sent to another host base that operates the same type of aircraft; otherwise, (if ALTDEF is zero) the maintenance will be further deferred until the aircraft's host base is open.
CEOVER	Number of minutes overtime permitted civil engineers to finish an ongoing task.
LEVLAC	If zero, aircraft transfer demands are satisfied in the order the demands are initiated; if not zero, demands are filled so as to maintain a similar fill rate.
NOBODM	If "1," delayed cratering munitions are assumed to detonate when delivered, without any delay.

Card Type #4/4

SPARE1 . . . SPARE9	Provides nine unassigned variables that are available in the BASIC labeled common statement for temporary use with user-constructed logic.

Card Type #4/5

This card allows users to change the airbase attack times of up to 24 attacks. The nominal attack times are originally specified in TSARINA and are then transferred to TSAR; if only the times for the attacks, not their sequence, are to be changed, CT4/5 may be used rather than rerunning the entire problem with TSARINA. The new times specified with these inputs are by attack number, where the attack number is defined by the order that the CT40 cards are read in subroutine INPUTD. The times for any attack up to attack #24 may be changed using CT4/5. All times are to be expressed in TTU.

SPECIFICATION OF TASK CRITICALITY AND AIRCRAFT STATUS

The importance of each aircraft maintenance task for each of the missions that a type of aircraft may be scheduled to fly is specified with a two-digit number between 1 and 99 on the CT5 card, discussed in the following subsection. The same criticality is associated with all task elements in a task network; the value need only be entered on the CT5 for the "root segment." The capability of each aircraft to fly a particular type of mission at any given time is also expressed with a number interpreted in the same way.

The interpretation of these numbers is shown in Table 1. When the task criticality or the aircraft flying status is specified by one of the numbers along the top, its status for a particular type of mission is recorded in the row corresponding to that mission. If the entry in the table is 1, the task is critical for that mission, or the aircraft has a deferred task preventing that mission from being flown. If task criticality is 32, the aircraft may be ferried; if it is 33, the aircraft is grounded until the task has been accomplished.

If a task may be deferred only until the end of the day, task criticality is increased by 33; if a task may be deferred only for LTHDEF sorties, task criticality is increased by 66.

If a negative value (–1 to –99) is specified for task criticality on a CT5 card (for a root segment), that implies that that task (and all other tasks in the same network) may *not* be deferred 1 to 99 percent of its occurrences but may be deferred until night in all other instances.

Table 1

CRITICALITY CHART

	Task Criticality or Aircraft Status																															
Mission	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	1
2	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	1
3	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	1
4	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

TASK REQUIREMENTS DATA

Card Type #5

On-equipment aircraft maintenance tasks are entered here. These can include scheduled maintenance, phase inspections, unscheduled maintenance, and battle damage tasks, as outlined in Table 2 of Vol. I. As explained in Sec. IV of that volume, the organization and sequencing of all aircraft maintenance tasks, other than the early morning inspections and phase inspections, are controlled independently for each aircraft type at each airbase using CT29. Tasks may be handled either individually or as collections of unscheduled tasks associated with the various work centers or shops. The first 24 shops should be used for such task collections; Shop #25 (the "flight line" shop) and the preflight Shops #27, #28, and #29 are handled somewhat differently (see Secs. V and VI, Vol. I) and have a "flexible overtime" policy.

Resource requirements (time, personnel, and equipment) are entered following the cognizant shop number and the number of the part, if any, that is associated with the task. If the task requires munitions or TRAP, that requirement is imposed by entering 10000 + 400 × Number + Ammo Type, or 20000 + 400 × Number + TRAP Type, in the "Part" column. If the shop facility itself is required for the task, or if the task must be accomplished at a rear base, those constraints are specified by the entry in column 10 (see note to Fig. 6). If the task time varies, the mean time (in TTU) should be entered in cols. 16–19, and the number of the uncertainty distribution in col. 20; see App. I in Vol. III for the definition of the nine available distributions.

If the base is structured in a 66-5 organization (COMO, combat-oriented maintenance organization), and specialists of the type required are assigned at squadron level, the numerical designation of personnel assigned to the first squadron shall be specified for the task. Equipment specifications are handled in a comparable manner. If only one set of specialists or one piece of equipment is required, it should be entered in the left position. If one of the two sets of personnel is a "load team" (see CT15/1), it *must* be placed in the left position. As will be noted, the number of the first of any alternative procedures should be entered in columns 56–60.

Task networks are specified by the entries in the columns provided for subsequent and parallel task numbers and for the rejoin flags. All segments of a task network are to be associated with the same shop, even though personnel and equipment may be borrowed from another shop for some of the task segments. Task networks will be

"chained" if the last entry of a network limb is the root segment for another network. Care must be taken that no two networks can point to each other.

In a task network, a segment that immediately follows a segment that specifies a part, may be made contingent on whether the part in the preceding task was required; if a part was not required, the task so designated will be skipped and subsequent tasks will be considered immediately. This option is activated by placing a −1 in the part column of the task, or set of parallel tasks, that follow the task with the part.

The task probability entered with CT7 determines usage for the root segment of the unscheduled maintenance tasks entered with the shop collections. The task probabilities entered in columns 41–44 with CT5 apply only to the segments of a task network that follow the root segment and to (most of) those tasks that are entered into the shop-task sequence using CT29 (the only exceptions are the decontamination task, if any, and the tasks for loading basic munitions; the latter are controlled by the probabilities that such munitions are retained from the previous missions, which are entered with the mission data on CT16).

When a network splits into two or more parallel paths, some of the paths may be mutually exclusive, others not. *For the task segments that begin each parallel path,* the sign of the task probability defines how that path is to be treated; all paths for which the task probability is negative are treated as mutually exclusive; tasks with positive probabilities are not mutually exclusive.

If any parallel paths later rejoin, the number of the task segment that immediately follows that junction shall be entered in the "rejoin flag" column of each initial task. It is also mandatory that any parallel paths that split and rejoin must all split and rejoin at the same junctions. Furthermore, once begun, any parallel paths that later rejoin *must* rejoin; that is, the likelihood that activity continues along the path until the junction is reached *must* be unity.

"The network mean time" normally is estimated internally and need be entered only for task networks that are not included in the shop collections; for such networks it should be the mean time through the entire task network. The "incompatibility pointer" defines the position in the LISTIN array (CT19) that contains the first item incompatible with the current task, as explained for CT19.

The criticality of each task for any of five missions is specified with a two-digit integer that may be either positive or negative. When it is *positive* its binary equivalent

defines task essentiality (1) or deferrability (0) for each of five missions (see Table 1); if the task may be deferred only until the end of day, the criticality indices should be increased by 33; if the task may be deferred only for LTHDEF sorties, the criticality indices should be increased by 66. When the value entered for criticality is *negative*, the absolute value is interpreted as the percentage of the time the job must be accomplished before another mission is flown; otherwise it is treated as a task that may be deferred until night. This datum need be entered only for simple tasks and for the root segment of a network; if no value is entered, the default value is 32.

The heat factor applicable to a task is entered in columns 76–79, unless the default value for flight-line tasks is appropriate. The MVDC entry controls how task time will be varied with MOPP, and the KCAL entry indicates the kilocalories per hour (+10) that are generated on the particular task.

All tasks that are not to be categorized as unscheduled maintenance are identified by entering a 1 in column 45. An entry in column 80 designates whether cross-trained or task-assist-qualified personnel are able to handle this task. When records are maintained on disk, an alphanumeric description of the task may be entered in columns 81–100.

Sample Data

The first task listed in Fig. 6, Task #1, is assigned to Shop #2 and is carried out by one Type #2 maintenance personnel, using a piece of #2 equipment (AGE). The mean task time is 30 minutes (i.e., 10 TTU) with the variance specified by distribution #2. No part is associated with this task. If the resources for this task are unavailable, no alternative procedure is available. The task must be accomplished before any mission is flown (default criticality).

The #2 Task, carried out by two Type #1 and three Type #2 personnel, using both #2 and #3 AGE, is the root segment of a simple network; this initial task requires 1 hour and 15 minutes (25 TTU). The task is critical only when the second or third mission type is to be flown (criticality is 7; see Table 1). The heat factor for Task #2 is specified as 314, thus overriding the default value of 118. If any of the incompatible tasks (beginning in the 61st field of the LISTIN array) are in process, the task may not be started. Three mutually exclusive Tasks, #3, #4, and #5 (denoted by the minus probabilities), follow Task #2: Task #3 is required 40 percent of the time; #4, 35 percent, and #5, 25 percent. An alternative procedure (#1) can be used for task segment #3, but for no other.

Card Type	Task Number	Shop Req.*	Shop No.	Part Number	Time Mean TTU	D	Personnel Team 1 Type	Team 1 No.	Team 2 Type	Team 2 No.	Equipment Eqp 1	Eqp 2	Network Mean Time TTU	Task Prob. x 1000	U**	I C***	f	Part Prob. x 100	Incompat Pointer	Alternate Procedure	Parallel Task	Rejoin Flag	Subsequent Task	Heat Factor NVDC	Heat Factor KCAL	[illegible]
5	1		2		10	2	2	1			2															
5	2		2	1	26		1	2	2	3	2	3							A				8	3	14	
5	3		2		15		3	2						-400						1	A					
5	4		2		30		1	2			2			-350							5					
5	5		2		40		2	1						-250							0					
5	6	2	3	2	20		3	3			3							60	1							
5	7		3	3	15		3	2			2							50		2			8			1
5	8		3	-1	40		3	1						400									9			
5	9		3		10		3	2			2			300									0			1
5	18		10	9	14		8	1										45					19			
5	19		10		15		8	2						-330							23	21	20			
5	20		10	10	25		8	1						1000				77					21			
5	21		10		16		8	1	7	1				700									22			
5	22		10	15	24		8	2						800				75								
6	23		10	12	19		8	1			7			-150				100			24	21	21			
5	24		10	14	32		8	2						600				60			25	21	21			
5	25		10	-1	12		8	1			7			-520									26			
5	26		10	11	32		8	1						800				100					27			
5	27		10		14		8	2			6	7		-600							28					
5	28		10	13	24		7	1						-400				100								

*Maintenance requirement
- = 1 Shop not required, maintenance required at host for DOB aircraft
- = 2 Shop not required; rearward maintenance required for COB and DOB
- = 3 Shop not required; rearward maintenance required for all bases
- = 4 Shop required
- = 5 Shop required; maintenance required at host for DOB aircraft
- = 6 Shop required; rearward maintenance required for COB and DOB
- = 7 Shop required; rearward maintenance required for all bases

**Enter a "1" for all tasks that are not unscheduled maintenance

***Personnel Substitutability 1 if cross-trained personnel may be used; 2 for task-assist-qualified personnel; 3 if either may be used

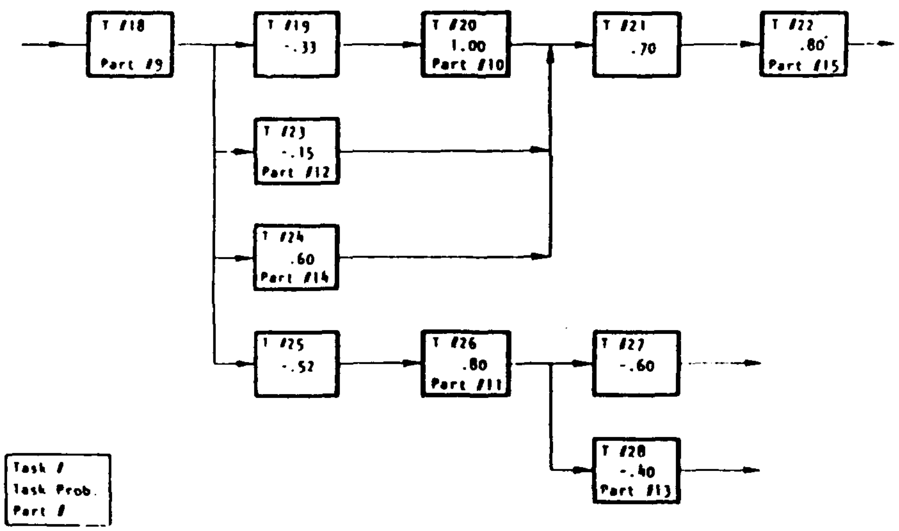
f_A minus criticality is the probability task cannot be deferred.

Fig. 6—Aircraft maintenance task requirements

Task #6 requires three Type #3 personnel an average of 1 hour (20 TTU) using a Type #3 AGE; furthermore, it is necessary that the aircraft be ferried to the rear maintenance base to carry out this task (specified by the 3 in column 8). A Type #2 part is required in 60 percent of the occasions when this task arises. If any of the tasks or shops listed in the incompatible task list (beginning in the 61st field) are in process, this task must wait.

Task #7 is the root segment for a simple task network that is assigned to Shop #3; Task #7 takes two Type #3 personnel 45 minutes to complete. Part #3 is required for Task #7 on 50 percent of the occasions. As designated by the −1 in columns 14–15, Task #8 is considered only when Part #3 is required on the preceding task; when that has occurred there is a 40 percent chance that Task #8 is required. If a part was not required, or if it was and Task #8 also was required, then there is a 30 percent chance that Task #9 must be performed to complete the task. If two Type #3 personnel are not available for Task #7 or Task #9, personnel that have been cross-trained to replace these specialists could be used; one Type #3 person is required when Task #8 must be handled, however, because no personnel substitutability is indicated for this element of the network.

Task #18 is the root segment for the complex task network sketched below; this network involves 11 task segments and seven parts:



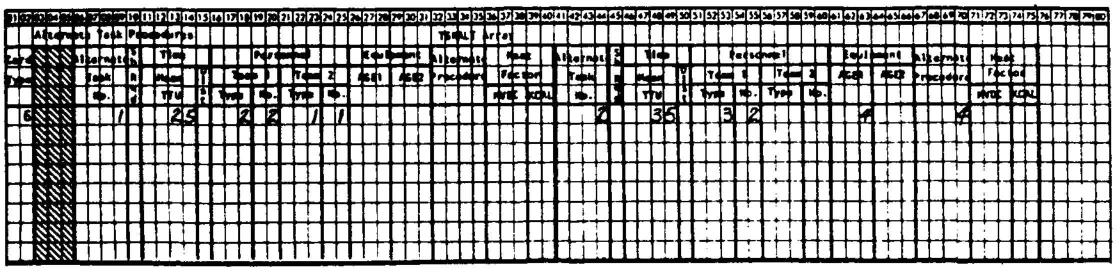
Following completion of the root segment task, at most one of the three mutually exclusive Tasks #19, #23, or #25 (denoted by the minus probabilities) is selected, and

there is a 60 percent chance that Task #24 also must be done. If Task #24 and either #19 or #23 are required, both paths must be completed before a check is made to see if Task #21 is required. Also, if part #9 had not been required with Task #18, and Task #25 was selected from the mutually exclusive set, that task is bypassed (as dictated by the −1 in the parts column for Task #25) and a check is made to see if Task #26 is required.

Other tasks, not shown in Fig. 6 but listed for the sample problem in Fig. 17 in Sec. XX, include the shelter refueling Task #41 (see CT15/1), the hot-pit refueling Task #51, an aircraft decontamination Task #52, and the scheduled maintenance tasks for uploading auxiliary fuel tanks (#42) and for loading the basic munitions (#43 and #44). The coded part numbers for the last three of these tasks specify two Type #5 TRAP (20000 + 400 × Number + Type), two #12, and one #11 munition (10000 + 400 × Number + Type). The fuel tanks are required after 60 percent of the sorties; the expenditure rate for the basic munitions is controlled by mission with CT16. Task-assist-qualified personnel may be used for the fuel tank and #11 munitions tasks; either cross-trained or task-assist-qualified personnel may help with the #12 munition task.

The five Tasks #101 through #105 (also shown in Fig. 17) constitute the battle-damage repair tasks as specified on CT15/2 for aircraft Type #1; these apply for all missions of this type of aircraft except mission #2, for which CT15/3 specifies that Tasks #103 through #106 apply. Tasks #106 through #108 are specified on CT15/2 as the tasks that are required to repair damage sustained by aircraft Type #1 from airbase attacks. Of the various battle damage tasks, only Task #107 may be deferred. For Tasks #103 and #107 the aircraft must be ferried to the rear maintenance base for repair; if Tasks #101, #104, or #106 are also required, they will need to be repaired before the aircraft is ferried, because they may not be flown when any of those three tasks are outstanding—i.e., the task criticality is 33.

Card Type #6



Alternative procedures and resource requirements for on-equipment maintenance tasks are specified here. The task number for the first alternative procedure is entered in columns 56–60 on CT5, and refers to the location of the resources for the alternative procedure in the TSKALT array; these numbers are a distinct set, different from those that define the basic task procedures on the CT5 cards. Alternatives to an alternative procedure may be specified in columns 32–35 (67–70) on the CT6 cards. The heat factor for alternative task procedures may be uniquely specified or will be set to the default value for flight-line tasks if not entered.

Sample Data

Alternate procedure #1 is an alternative to Task #3; two Type #2 and one Type #1 specialist can do the job instead of two type #3 personnel, but they require an additional half-hour. Alternate procedure #2 indicates that the same personnel, working with a #4 AGE instead of the normal AGE, could do Task #7 in an extra hour (35 rather than 15 TTU). Alternate procedure #4 is an alternative to alternate procedure #2, and thus also to Task #7.

Card Types 6/88 and 6/99

Requests for Automatic Generation of Alternate Task Procedures

Card Type		Nominal Personnel Type	Substitute Personnel Type	Time Mean	D	Heat Factor HVDC	Heat Factor KCAL	Substitute Personnel Type	Time Mean	D	Heat Factor HVDC	Heat Factor KCAL	Substitute Personnel Type	Time Mean	D	Heat Factor HVDC	Heat Factor KCAL	Substitute Personnel Type	Time Mean	D	Heat Factor HVDC	Heat Factor KCAL
6	88	3	7	110				-1	-40													

Card Type		Nominal Equipment Type	Substitute Equipment Type	Time Mean	D	Heat Factor HVDC	Heat Factor KCAL	Substitute Equipment Type	Time Mean	D	Heat Factor HVDC	Heat Factor KCAL	Substitute Equipment Type	Time Mean	D	Heat Factor HVDC	Heat Factor KCAL	Equipment Type	Time Mean	D	Heat Factor HVDC	Heat Factor KCAL
6	99	2	9			246																

These card types permit a single entry to be used to automatically generate a number of alternate task procedures. When the alternate procedures simply involve substitution for one type of personnel *or* one type of equipment, one entry will generate alternate procedures for *all* tasks that use the specified personnel or equipment. Furthermore, if the mean time X is positive, each task will be X percent as long as the basic task, and if it is negative, the mean time will be (-X) TTU longer than the basic task; the time distribution and heat factor may also be changed globally.

Sample Data

The first card directs that alternate task procedures be created for all tasks (CT5) that use Type #3 personnel. The first set of such alternate task procedures use Type #7 personnel instead of Type #3, and take 110 percent as long as the basic (CT5) task. The second set simply does not require personnel to replace the Type #3 personnel (i.e., –1 denotes none), but the total time is increased two hours (40 TTU). The second card directs that another set of alternate tasks be created that substitute Type #9 equipment for Type #2 equipment but have a heat factor of 246.

The "0" for the mean time implies the default value: 100.

Card Type #7

SHOP TASK DATA - SAPTSK Array -

Card Type	AC Type	Task No.	Prob x 10000	Prob Undetected x 100	Task No.	Prob x 10000	Prob Undetected x 100	Task No.	Prob x 10000	Prob Undetected x 100	Task No.	Prob x 10000	Prob Undetected x 100	Task No.	Prob x 10000	Prob Undetected x 100
7	1	1	245	50	2	500	50	6	834	50	7	460	50	18	392	50

These cards control the incidence per sortie of the on-equipment maintenance tasks associated with the shop task collections. The probability of a malfunction per sortie (multiplied by 10,000) is entered for each simple task and for each task network; i.e., for each root segment. These data are entered separately from the task data entered with CT5, so that the same tasks may arise on different types of aircraft with different probabilities. These cards also supply the probability that malfunctions will not be detected by the aircrew before recovery. Aircraft operating from dispersed operating bases will return directly to their host base when malfunctions are detected; otherwise, they will have to be refueled at the DOB and then be ferried to their host. These cards must be entered after CT5.

Sample Data

This sample indicates that Tasks #1, #2, #6, #7, and #18 are required after 2.45, 5.0, 8.34, 4.6, and 3.92 percent, respectively, of the sorties flown by aircraft Type #1. For each task there is a 50 percent chance that it will be undetected until the aircraft has landed.

Card Type #8

The parts removed from an aircraft may be repaired, they may be NRTSed to another location, or they may be condemned. This card type is used to define the resource requirements for their repair. All parts that are not condemned, or automatically NRTSed, must be processed by the appropriate shop. (A part is automatically NRTSed only when the NRTS rate is 101.) When a part is first removed from an aircraft a check is made to see if it should be condemned; if not, a check is made to see if it is to be NRTSed. If it is condemned, or is to be automatically NRTSed, no shop action is required. All other parts are sent to the appropriate shop for action.

The repair of a part may involve either a specific procedure or one of two or more different procedures. When there are two or more procedures, the appropriate procedure is selected on the basis of the probability of the several procedures, except in the case of a part that is to be NRTSed; those parts are checked using the first procedure. Each procedure may involve a series of repair steps, and each step in a procedure may have a specified probability of being required. A repair is completed whenever a subsequent step is not required.

An aircraft part may be repaired without the requirement for any subordinate parts, or the part may be represented to be composed of one or more shop replaceable units (SRUs). The repair of a part (LRU) with SRUs involves the decision as to which SRU is faulty, and the necessary work to replace that SRU. The procedure to replace each SRU is specified separately, and only one procedure (and therefore one SRU) is chosen to repair the LRU. The format used with the CT8 cards (Figs. 7 and 8) depends upon which type of part is being treated.

The CT8/1 format (Fig. 7) is used for parts with only one repair procedure; the CT8/2 format is used for parts that have several possible repair procedures and/or SRUs; the CT8/3 (Fig. 8) format is used to enter the multiple procedures, SRU replacement procedures, and SRU repair procedures; and the CT8/4 format is used to specify subsequent steps for any of the parts repair procedures. The part number specified in the TSKRQT array (on CT5) denotes where the REPRQT array should be entered for data regarding its repair;[3] therefore, the parts associated with various aircraft types must each

[3]When two or more of the same type of part are used on an aircraft (or two or more like SRUs in an LRU), i.e., QPA > 1, the different locations are associated with different part numbers, and one of these is identified as the "Prime" with CT35/4; repair procedures should be specified with CT8 only for the "Prime" part.

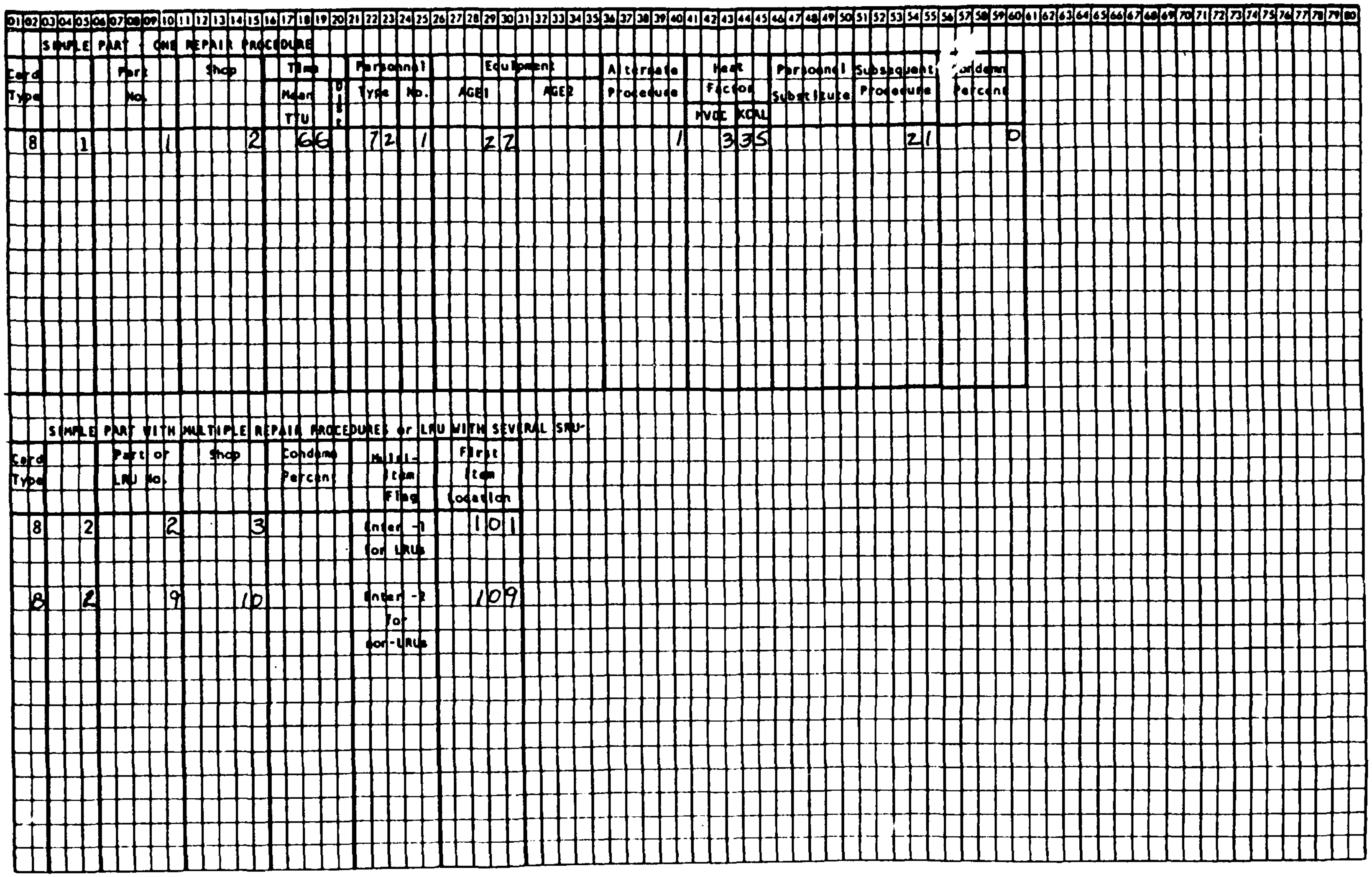


Fig. 7—Aircraft parts repair requirements

be assigned a unique number, except for parts that are common to two or more types of aircraft. The heat factor that is appropriate in a chemical warfare environment can be entered for each step of each procedure on the CT8/1, CT8/3, and CT8/4 cards, if the default value for backshop tasks is inappropriate. If the resources required for any step of any repair procedure are not available, the program will first check whether cross-trained personnel or task-assist personnel are to be considered for the task, and then will check whether the user has specified other ways in which the required action may be accomplished. Pointers to these alternate repair procedures can be entered on the CT8/1, CT8/3, and CT8/4 cards; their requirements are then entered on the CT9 cards.

Parts that involve two or more repair procedures are entered with the CT8/2 format. If SRUs are to be distinguished, a –1 is entered in columns 24–25; if no SRUs are distinguished, a –2 is entered in the field. The location of the first repair procedure, or the first of the SRUs in an LRU, is specified in columns 26–30. The requirements for the various procedures and the requirements for diagnosing and replacing each of the SRUs in an LRU are entered using a CT8/3 (Fig. 8) format and are also stored in the REPRQT array.

When a part is to be checked in the shop before being NRTSed, the first procedure is always used when there are multiple procedures. If the probability of the first procedure is greater than zero, the same procedure may be selected when the part is to be repaired on base; otherwise the first procedure would be used only when the part is checked in the shop and NRTSed.

An SRU that is replaced to repair an LRU may itself be considered for repair. When it is removed it is checked to see if it should be NRTSed immediately without being checked in the shop. If it is to be checked, and then NRTSed or repaired, it is handled just like an LRU. Several alternate repair procedures may be specified and each may consist of several sequential steps; the first of these procedures is always used for an SRU that is to be NRTSed. The only difference is that no other parts may be identified as a requirement for the repair of an SRU.

Any of the procedures for repairing simple parts, LRUs, or SRUs may require a sequence of steps, each with its own probability and its own requirements for personnel, equipment, and time (except that a component that requires an avionics intermediate shop (AIS) station for repair can have only one AIS station specified in the task sequence). The CT8/4 format should be used for entering repair requirements for all steps other than the first.

OPTIONAL REPAIR PROCEDURES and SRU DIAGNOSTIC and REPLACEMENT PROCEDURES

Card Type	OPT	Repair Procedure of SRU	Next Item Location	Time Mean TTU	D	Personnel Type	Personnel No.	Equipment AGE1	Equipment AGE2	First SRU Repair Procedure	Item Prob ×100	Heat Factor HVDC	Heat Factor KCAL	Personnel Substitution	Alternate Procedure	Subsequent Procedure
8	3	101	102	68		73	1	3		131	50			1	3	151
8	3	102	103	96		73	1			134	30			1	4	171
8	3	103	601	44		73	1				10					
8	3	601	0	60		73	1			-1	10					
8	3	109	110	120		78	2	17	32		20			1	5	
8	3	110	111	80		78	1	17	31		55			1		
8	3	111	0	100		78	1	17	32		25				6	
8	3	131	132	40		77	1	16			0					
8	3	132	133	60		77	1	16			20					
8	3	133		20		77	1	16			80					161

Format for all subsequent repair steps

Card Type		Repair Procedure	Time Mean TTU	D	Personnel Type	Personnel No.	Equipment AGE1	Equipment AGE2	Step Prob. ×100	Heat Factor HVDC	Heat Factor KCAL	Personnel Substitution	Alternate Procedure	Subsequent Procedure
8	4	21	20		73	1	22		75					22
8	4	22	15		72	1			60					
8	4	151	30		74	1			80					152
8	4	152	20		73	1			50					
8	4	171	15		74	1			66					172
8	4	172	30		77	1			55					

Fig. 8—Aircraft parts repair procedures

A repair procedure on CT8/3 that is numbered less than NOPART and does not require an SRU *must* be distinguished from one that requires an SRU with a –1 entry in columns 39–40. If the repair procedures that do not involve an SRU are numbered between NOPART and NOREP, the size of arrays that use NOPART as a dimension can be minimized. (Furthermore, the requirement for a negative entry will be avoided, because that entry is made automatically except for those LRUs that have procedures that do not require an SRU and are numbered less than NOPART.)

Each alternative procedure or SRU entry also specifies (1) the likelihood that that procedure is required or that the SRU is faulty, and (2) the number of the next procedure or SRU, if any. The probabilities associated with the alternative procedures, or with the SRUs in an LRU, must sum to 100.

When an SRU may itself be repaired, the location of the first of the one or more procedures that may be specified for that repair is listed in columns 36–40 of the SRU replacement data. If two or more procedures are given for the repair of an SRU, the particular one required in a given instance is selected on the basis of the individual procedure probabilities entered in columns 41–45. As with LRUs, the first of the SRU procedures specifies the resources required to check an SRU that is to be NRTSed; if the probability of the first procedure is not zero it may also be selected for an SRU that is to be repaired on base.

Sample Data

Repair procedures are illustrated for a simple part (#1), an LRU (#2), a simple part with several possible repair procedures (#9), and for an SRU (#101). Part #1 requires a three-step repair; step #1 uses one Type #72 specialist for 3 hours and 18 minutes to repair or to check for a NRTS action, using a piece of #22 equipment; steps 2 and 3 (using procedures #21 and #22) take 60 minutes and 45 minutes, respectively, using different personnel and/or equipment. An alternative procedure (#1 on CT9) is listed for the first step.

The LRU #2 has 3 SRUs (#101, #102, and #103) that fail 50, 30, and 10 percent of the time, respectively; in the other 10 percent of the repairs no SRU is required and repair procedure #601 is used. When the LRU #2 failure is due to a faulty #101 SRU, a three-step repair procedure is required, i.e., procedures #101, #151, and #152; similarly for a #102 SRU. Furthermore, the first of these steps each has an alternate procedure, and both of these SRUs may themselves be repaired. As will be noted in the sample

data, the times and resources for each of the repair procedures differ. When LRU #2 must be checked before it is NRTSed, the resources associated with procedure #101 are used.

Part #9 is repaired in Shop #10 using one of the three procedures, #109, #110, or #111; the four-hour procedure (#110) is done most commonly (55 percent), but the job often takes five or six hours; the six-hour job is required to determine that the part must be NRTSed. Alternate procedures are listed for the first and third of these procedures.

The #101 SRU is repaired by one of two procedures—#132 or #133; procedure #131 is used only when the SRU is checked and NRTSed. The personnel and equipment are the same for all these procedures; procedure #132 is used 20 percent of the time and takes three hours, and procedure #133 is used 80 percent of the time, and is a multistep procedure.

Card Type #9

Alternate Parts Repair Procedures — REPALT Array

Card Type	Procedure No.	Time Mean TTU	Dist	Personnel Type	Personnel No.	Equipment AGE1	Equipment AGE2	Alternate Procedure	Heat Factor WUC	Heat Factor KCAL	Procedure No.	Time Mean TTU	Dist	Personnel Type	Personnel No.	Equipment AGE1	Equipment AGE2	Alternate Procedure	Heat Factor WUC	Heat Factor KCAL
9	1	105		73	1															
9	3	92		77	1	11														

Data entries for substitute parts repair procedures are structured analogously to those for alternative on-equipment tasks (CT6) and are stored in the REPALT array. If a heat factor is not specified, the default value for backshop repairs will be applied.

Sample Data

One Type #73 person can repair Part #1 in 3-1/4 hours without any specialized AGE; see comments on CT8. Alternate procedure #3 can be used in replacing a #101 SRU in LRU #2, using a different specialist and a different equipment, but the alternate procedure takes 1 hour and 12 minutes longer.

Card Types #9/88 and 9/99

Requests for Automatic Generation of Alternate Parts Repair Procedures

Card Type		Nominal Personnel Type	Substitute Personnel Type	Time Mean	D	Heat Factor MVDC	Heat Factor KCAL	Substitute Personnel Type	Time Mean	D	Heat Factor MVDC	Heat Factor KCAL	Substitute Personnel Type	Time Mean	D	Heat Factor MVDC	Heat Factor KCAL	Substitute Personnel Type	Time Mean	D	Heat Factor MVDC	Heat Factor KCAL
9	88																					

Card Type		Nominal Equipment Type	Substitute Equipment Type	Time Mean	D	Heat Factor MVDC	Heat Factor KCAL	Substitute Equipment Type	Time Mean	D	Heat Factor MVDC	Heat Factor KCAL	Substitute Equipment Type	Time Mean	D	Heat Factor MVDC	Heat Factor KCAL	Substitute Equipment Type	Time Mean	D	Heat Factor MVDC	Heat Factor KCAL
9	99																					

These card types provide for the automatic generation of alternate parts repair procedures, using input formats analogous to those for CT6/88 and CT6/99.

Card Type #10

EQUIPMENT REPAIR REQUIREMENTS DATA - AGEREP ARRAY -

Card Type (01–02)	Equipment Type (06–10)	Shop (11–15)	Break Prob. × 10000 (16–20)	Time Mean TTU (21–25)	Personnel Type (26–28)	Personnel No. (29–30)	Equipment AGE1 (31–35)	Equipment AGE2 (36–40)	Alternate Procedure (41–45)	Heat Factor NVDC (46–48)	Heat Factor KCAL (49–50)	Personnel Substitution (51–55)	Subsequent Procedure (56–60)
10		Or next procedure	Or procedure probability × 1000	Or minus station type for AIS	Enter -1 for alternate procedures		Enter first alternate procedure						
10	2	2	626			-1	51						
10	51	52	400	40	72	1							
10	52	53	100	60	72	1	20	21					
10	53		500	2400									65
10	66		750	2	73	1							67
10	67		500	4	72	1			68				
10	68			6	73	1							
10	18	10		-3									

For repair purposes, support equipment is divided into two categories: those that are either serviceable or must be repaired, and those that also have an intermediate, partly mission-capable state. The former are repaired with the procedures that are entered with CT10 cards and are stored in the AGEREP array. The latter category, consisting primarily of the AIS used for testing and repairing avionics on late model aircraft, are described with CT22/66 and CT22/77.

For the first of these categories one or more procedures may be specified for repairing each type of equipment; and each procedure may consist of one or more steps. When more than one procedure is listed, they are assumed to be mutually exclusive and the one that is required for any particular repair is selected by a random process. The basic data appropriate for each type of equipment are found in the column of the AGEREP array that corresponds to the number designating the type of equipment. Data for multiple repair procedures, for any subsequent steps in a repair procedure, or for alternative repair procedures, should be located in columns of the AGEREP array that do *not* correspond to an actual type of equipment and *must* have column numbers that are greater than the equipment number that they are associated with.

The shop to which the equipment repair is assigned and the probability (times 10000) that the equipment is broken following each use are entered in columns 11–15 and 16–20; when a single procedure is appropriate, the time, personnel, and equipment are entered next. If the repair requirements vary depending upon circumstances, a –1 is entered in columns 29–30 of the basic entry, and the entry in column 31–35 specifies the location in the AGEREP array of the first of the multiple repair procedures. For those

procedures, columns 16–20 contain the probability (times 1000) that that particular procedure will be required, and columns 11–15 specify the location of the next procedure. The next of any subsequent steps in a repair procedure is entered in columns 56–60.

In all cases a substitute set of resources may be specified for use if resources are unavailable for the nominal repairs; the substitute procedure (i.e., alternate) must be identified by a –1 in columns 14–15 following the procedure number in columns 6–10. A heat factor may be specified uniquely for all steps in the equipment repair procedures and for all substitute procedures, when the default value for backshop work is inappropriate.

An equipment that also is an AIS station, is distinguished by entering the negative value of the number that identifies the station type in columns 21–25. This permits one number to be used to describe the item as a type of equipment, and another to describe it as an AIS station. The only information to be entered on the CT10 card for an AIS station is the shop number and the minus value of the station number.

Sample Data

Repair requirements are shown for Type #2 equipment. The repair is assigned to Shop #2; the likelihood that a piece of #2 equipment is found faulty following each use is 6.26 percent. One of three different procedures (#51, #52, or #53) may be required to repair a Type #2 equipment; 40 percent of the time one Type #72 personnel can repair it in two hours; 10 percent of the time the same specialist takes four hours using two pieces of equipment, and 50 percent of the time five days (2400 TTU) must elapse first before the repair may start (this type of procedure, one that consumes time but no personnel or equipment, can be used to approximate the effect of waiting for a critical piece-part from another location). After that long delay, two short steps (#66 and #67) complete the repair; the second step has an alternate specified as procedure 68.

The last entry illustrates how the AIS equivalent of an AGE type is identified. In this instance, a #3 type AIS station is identified as a piece of Type #18 equipment; the minus sign denotes the special nature of this entry.

Card Type #11/1

01–80		MUNITIONS ASSEMBLY REQUIREMENTS DATA - MUNRQT ARRAY -																			
Card Type		Type Ammo**	Time Mean TTU	Personnel Type	Personnel No.	Equipment AGE1	Equipment AGE2	Alternate Procedure	Quan*	PS	Heat Factor (MVDC / KCAL)	Type Ammo**	Time Mean TTU	Personnel Type	Personnel No.	Equipment AGE1	Equipment AGE2	Alternate Procedure	Quan	PS	Heat Factor (MVDC / KCAL)
11	1	-1	40	65	3	21			6	1	338	2	120	64	4	23					
11	1	-3	70	65	3	21	23					4	30	64	3	21			4	2	
11	1	5	105	64	4	23		21			432	-6	95	65	2	23				2	
11	7	21	140	64	4																

*Quan - Number of weapons assembled in mean time

**Enter unguided munitions using a minus "type" number

PS - Personnel substitutability

Resource requirements for assembling munitions are specified and stored in the MUNRQT array; the number of the munitions type determines the column in that array in which the data are filed. Up to NOWEAP types of munitions may be included. The components that are required to assemble munitions will also be accounted for when those requirements are specified with the CT11/2 cards, below. The quantity of munitions to be assembled for each task should be selected such that the buildup time is no greater than two to three hours, so that the simulated assembly activities will be responsive to sudden shifts in munitions requirements. The default value for the number of munitions assembled is 12. The heat factor for each of the munitions assembly procedures may be specified uniquely when the default value for this generic task type is inappropriate. To permit distinct sets of facilities to be specified for the assembly of guided and unguided munitions, a minus sign should precede the munition type number of unguided munitions so that they may be distinguished from guided munitions.

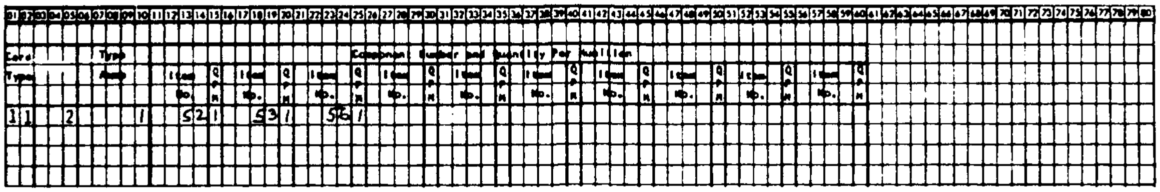
The requirements for substitute procedures, when specified, are also filed with these cards in the MUNRQT array; these data should not be filed in columns defined by any of the munition types considered.

Sample Data

Assembly requirements are shown for six types of munitions. The assembly of six Type #1 munitions takes three Type #65 personnel two hours (40 TTU) using a unit of Type #21 equipment. If available, cross-trained personnel may replace the Type #65 personnel in assembling the Type #1 munitions. The heat factor for this task is 338. For assembling #4 and #6 munitions, task-assist-qualified personnel may assist, but not

replace, the normal personnel. In one instance (the #5 munitions) an alternative procedure permits assembly without special equipment, but requires an additional 1-3/4 hours (35 TTU). The default heat factor is to be used for procedures #2, #3, #4, and #6. Munition Types #1, #3, and #6 are unguided munitions; this is designated by the minus sign preceding the type number.

Card Type #11/2



Munitions assembly will be based on the availability of the required numbers of component parts, when the components that make up a single munition are entered with a CT11/2 card. The basic munition type is entered in columns 6–10 and the component number and numbers per round can be entered for up to ten different kinds of components in columns 11–60. The numbers used to designate weapon components must be chosen so that they are greater than NOWEAP and not larger than NOMUN.

Sample Data

In this example, a #1 munition is composed of one #52 component, one #53 component, and one #56 component.

AIRCRAFT COMBAT LOAD DATA

Card Type #12

STANDARD COMBAT LOAD PREFERENCES — SCLP ARRAY

Card Type	Aircraft Type	Mission	Card No.	Priority #1/6 SCL #	Priority #1/6 Value	Priority #2/7 SCL #	Priority #2/7 Value	Priority #3/8 SCL #	Priority #3/8 Value	Priority #4/9 SCL #	Priority #4/9 Value	Priority #5/10 SCL #	Priority #5/10 Value
12	1	1	1	1	110	2	90						
12	1	2	1	3	100	4	60						

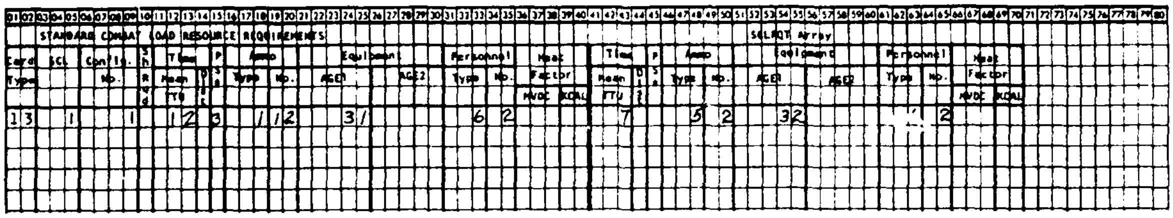
These cards permit the user to specify up to ten standard combat loads (SCL) for each combination of aircraft type and mission; two cards are required if over five SCLs are entered. The preferred loading is listed first; the least desirable load is listed last. An effectiveness proxy may be entered for each SCL; these values are summed during the simulation for each sortie that is launched and does not abort, and they provide an overall measure of effectiveness. The user must be careful to ensure consistency between the effectiveness proxies for the different types of aircraft and missions.

When the program is executed, resources are sought first for the preferred munitions, and then for the other (less effective) options. Definitions and resource requirements for loading the various SCLs are listed in the SCLRQT array and entered with the CT13 cards.

Sample Data

Combat loading preferences are shown for two missions for aircraft Type #1; primary and secondary choices have been defined in both cases. The first card image indicates that when an aircraft Type #1 is launched on a Type #1 mission, loaded with SCL #1, 110 effectiveness units are tallied; if the required munitions or TRAP are not available, mission effectiveness would drop to 90 when SCL #2 is used.

Card Type #13



The munitions loading requirements for the various SCLs are entered here. Since the SCL number denotes the column in the SCLRQT array in which the data are stored, distinct SCLs are required for each aircraft type, unless the time and resource requirements for loading the SCLs are the same. Resources needed to set up the aircraft configuration specified in columns 6–9 are handled with CT14. Either one or two sets of munitions may be specified. Different heat factors may be entered for each task. If the personnel and equipment requirements for the two tasks are the same, the tasks may be done in series if there are insufficient resources available for both. Otherwise, both must wait until all resources for both tasks are available, unless a subordinate SCL may be loaded.

Sample Data

These data specify that SCL #1 involves configuration #1 and that 12 Type #1 and 2 Type #5 munitions are to be loaded. Two Type #6 personnel require a #31 equipment for 36 minutes to load the #1 munitions, and the same team takes 21 minutes with a #32 equipment to load the #5 munitions. Cross-trained or task-assist-qualified personnel may be used for the first task (the 3 in column 15), but no substitutions are permitted for the second.

Card Type #14

AIRCRAFT CONFIGURATION RESOURCE REQUIREMENTS — CONFIG Array

Card Type	Config No.	Time Mean TTU	Dist	P S A	TRAP Type	Quan	Equipment AGE1	Equipment AGE2	Personnel Type	Personnel No.	Heat Factor HVDC KCAL	Time Mean TTU	Dist	P S A	TRAP Type	Quan	Equipment AGE1	Equipment AGE2	Personnel Type	Personnel No.	Heat Factor HVDC KCAL
14	1	10		1	2	1	34		6	2	360	8		1	4	1	28	8	6	2	231

The resource requirements and task times for all aircraft configurations are entered using CT14 cards. Either one or two tasks may be specified. The configuration number denotes the position of the data in the CONFIG array. If heat factors are not specified the default value for preflight tasks is used. When the aircraft returns from a mission, TRAP are returned to stock if inappropriate for the next mission. When the TRAP to be represented are auxiliary aircraft fuel tanks that *are consumed*—i.e., dropped in combat—they cannot be handled here, but *must be treated as a special task assigned to Shop #25* (see the CT5 discussion for these special tasks).

When an aircraft must be reconfigured to meet the requirements of a different mission (or because the required ammunition stocks are depleted and a different SCL must be loaded), the time required to remove the TRAP is assumed to be equal to the time specified here for equipping the aircraft. If either of the two sets of TRAP is common to the two configurations, only the dissimilar TRAP are "changed" during a reconfiguration. Also, as with the descriptors for other kinds of tasks, the personnel, equipment, and time requirements may be satisfied with a null entry; if, for example, the same crew, using the same equipment, loads two sets of TRAP in sequence, the descriptors for the second reconfiguration task could be limited to the TRAP, with null entries for personnel, equipment, and time; the total time would be listed for the first task.

Sample Data

Two tasks are required for configuration #1. In the first case two Type #6 personnel are to mount one #2 TRAP and will require 30 minutes using a piece of #34 equipment. The second task mounts one #4 TRAP in 24 minutes; two #6 personnel use Type #28 and #8 equipments. Cross-trained personnel may be used for either task, as designated by the 1 in columns 10 and 40.

MISCELLANEOUS AIRCRAFT DATA

Card Types #15/1 and #15/2

AIRCRAFT DATA — ACDATA ARRAY

Card Type	Card No.	AC Type	Delay Post-flight Min	Delay Pre-flight Min	Fuel Quantity	Fueling Task No.	Number Missions	Nominal Unsch Time Min	Nominal Cycle Time Min	Location First Part	Load Team Type	Load Team No.	Special AGE Type Numbers #1	Special AGE Type Numbers #2	Basic Munitions Type	No.	Type	No.	Type	No.
15	1	1	6		5	41	3	60	150	1	6	2	2	4	11	1	12	2		

Card Type	Card No.	AC Type	Transfer Delay Min	Battle Damage Tasks First	Battle Damage Tasks Last	Parts Recovery* %	Air Base Damage Aircraft Tasks First	Air Base Damage Aircraft Tasks Last	Battle Damage Spares Scrdles/AC	Alert Aircraft Personnel Type	Alert Aircraft Personnel No.	Alert Aircraft Equipment AGE1	Alert Aircraft Equipment AGE2	QDA Repr Base	Ground Abort Percent	Munitions Omission Penalty Percent
15	2	1	60	101	105	40	106	108	100	2	2	1		6		

*Probability that a part is recoverable from a salvaged aircraft

Miscellaneous aircraft data are entered using CT15/1, CT15/2, CT15/3, CT15/4, CT15/5, and CT16 cards. The first entries on CT15/1 permit the user to specify two delays during which no work may be done; one delay occurs immediately after the aircraft lands and one before the preflight maintenance tasks are begun. The values specified might be chosen to reflect inspections, various scheduling inefficiencies, or taxi time (if a taxi time is not identified explicitly on the CT17/1 card). The quantity of fuel and the appropriate task number for fueling are specified next. The approximate expected values that are entered for unscheduled maintenance time and for total sortie cycle time are used only for projecting the future supply of ready aircraft, and only for aircraft that have not yet been recovered; the user should derive these values from consideration of the various data entered with CT5, CT7, and CT29. The location, in the PRTLST array, for the first part eligible for salvage is entered in columns 46–50; only the parts numbers listed (CT28) in this array are considered for recovery when an aircraft is too badly battle damaged to be repaired, or when an aircraft has been destroyed during an air attack.

If the specifications for a munitions load team are entered, only one load team will be permitted to work on any given aircraft at a time; that constraint will be observed even when substitute or alternative personnel make up the required load team. For equipment types entered into the Special AGE fields, it is assumed that only one piece of such equipment need be present at an aircraft to satisfy all concurrent task demands. When an

dependent munitions requirements. These munitions are referred to as basic munitions. These entries and the retention data on CT16 are used in assessing the demands for munitions assembly; the resource requirements for uploading these basic munitions must be entered with CT5 cards (e.g., see Tasks #43 and #44 in the sample problem, Sec. XX).

The first entry on CT15/2 is an administrative delay that will be imposed when an aircraft is newly arrived on base. When aircraft battle-damage repair tasks are to be specified independently of a mission, the root segments of those tasks should be arranged in a numerically ordered set; the first and last task numbers of that set are entered next on this card. These tasks are each checked for those aircraft selected for battle damage at that point in the shop-task sequence (CT29) where Task #30000 has been specified. The next entry is the probability that each part will be recoverable from aircraft that are too badly battle damaged for repair and must be salvaged. A separate set of tasks may be specified for the aircraft damage inflicted by enemy airbase attacks; the root segments of these tasks should also form a numerically ordered set. If a number of sorties is entered in the battle damage spares column, quantities of the spare parts that would be required for battle damage repairs are automatically stocked at each base. The numbers of ABDR parts stocked are those that would be expected to be required if a given number of aircraft were each flown the specified number of sorties. (This stockage assumes that the sorties flown will be divided equally among the missions that the aircraft can fly.) The number of aircraft is either the number of each type initially at each base or, if OUTFIT is not zero, the number specified on the CT23/70 cards. All spare parts that must be replaced during ABDR tasks are condemned.

The next two entries on CT15/2 are used to specify any personnel or equipment that must be maintained with each aircraft to be placed on alert. Initializing the next entry with a "1" declares that this aircraft type may be designated for assignment to "special alert" (e.g., QRA) and will be given priority when aircraft shelters allocated to this role are specified on CT17/1; when a 1 is entered in this field, an aircraft alert requirement for the highest numbered mission that this aircraft type may be assigned to (col. 35 on CT15/1) is interpreted as special alert. The next entry specifies the base number of the rear base where aircraft of the specified type are flown for rear-base maintenance. The probability of a ground abort (times 1000) is entered next; a test is made against this value once between flights when an aircraft is considered for launching on a sortie.

The last three entries on the CT15/2 card provide the user with options for launching aircraft despite the unavailability of certain basic munitions. If any of these three fields is not zero (or null), the aircraft will be permitted to fly a combat mission without the corresponding munitions on CT15/1, and the entry is interpreted as the percentage degradation to be applied to the overall sortie effectiveness recorded in the effectiveness proxy when the aircraft is launched.

Sample Data

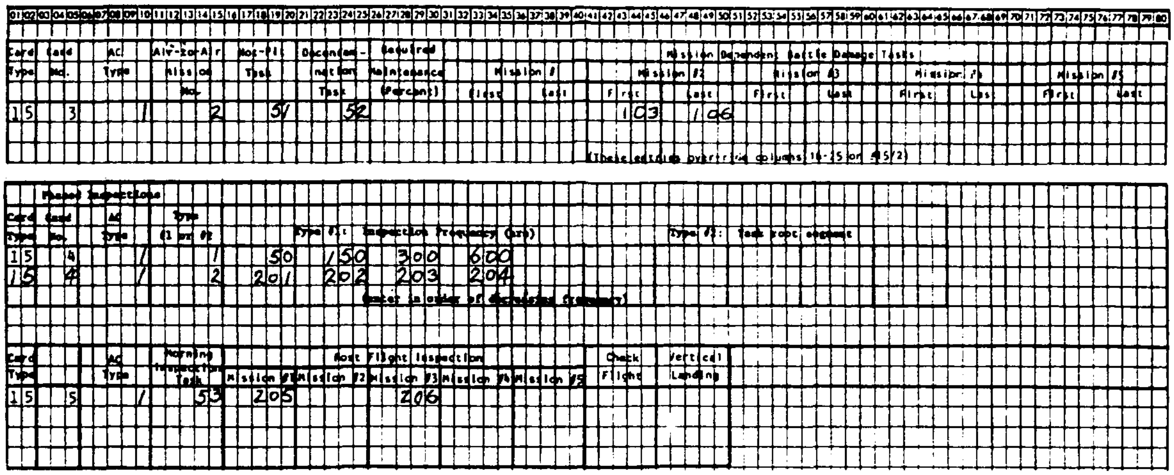
For Type #1 aircraft, there is a six-minute postflight delay. Fueling requires five units of POL; the time and personnel that are required are specified with Task #41. The aircraft can be assigned to three different missions. Approximate times for unscheduled maintenance and for a complete sortie cycle are 60 and 150 minutes. A munitions load crew consists of two Type #6 specialists; one piece of Type #2 or Type #4 equipment will satisfy all concurrent demands for either of those types of equipment. The basic munitions to be loaded for all missions consist of one Type #11 munitions and two Type #12 munitions. Note that these entries must be consistent with the basic munitions loading tasks #43 and #44, which are specified on CT29, and whose resource requirements are given by the appropriate CT5 cards.

When a Type #1 aircraft recovers at a different base, or is transferred to a different base, an hour is required for various administrative procedures. For aircraft that receive battle damage in combat, tasks are selected from the Task set #101 through #105, inclusive (except for mission #2, as noted below). For aircraft too damaged to be repaired, 40 percent of the parts are salvaged; those recovered are selected at random from the aircraft parts list specified with the CT28 cards.

Repair Tasks #106 through #108 are specified for aircraft damaged by air attack. Spare parts are stocked at each base for repairing battle damage sustained in flight operations, on the assumption each aircraft will fly an average of 100 combat sorties with the three mission types equally likely.

If an aircraft is to be placed on an alert, two #2 personnel and a #1 equipment must be assigned. When it is necessary for Type #1 aircraft to have maintenance done in the rear, the aircraft are to be ferried to Base #6. Since no effectiveness penalties are specified for either of the basic munitions, no sorties will be flown if either of those munitions is unavailable.

Card Types #15/3, #15/4, and #15/5



The CT15/3 card contains additional data that pertain to each specific type of aircraft. Entry of the number of an aircraft's air-to-air mission in the second field on CT15/3 specifies that the effectiveness proxy data for air-to-air missions of that aircraft type are to be listed separately from that of all other missions in the final results. An entry in the third field is interpreted as the task number for hot-pit refueling; whenever an aircraft of the appropriate type lands at a base that has a hot-pit refueling hydrant available for use at that time, the aircraft will refuel first, before any other tasks are started, and the normal refueling requirement will be canceled. An entry in the fourth field defines the task number of the root segment for whatever decontamination work is appropriate when the aircraft lands. Decontamination will be required if there is still any contamination on base, or if it is mandated by the special control switch that can be set at each base with the CT17/9 card (and can be reset exogenously with the Type #30 change using CT49 cards). An aircraft that requires decontamination will not be refueled at a hot-pit hydrant.

An entry in the fifth field on CT15/3 permits the user to simulate that a subset of the aircraft incur a disproportionate amount of the overall unscheduled workload, compared with the default case in which the probability of requiring each unscheduled task network is assumed to be independent of whether other networks are required. In the past, when TSAR has been run assuming task independence (using unscheduled maintenance data derived from data base prepared for the Air Force LCOM model) it has been found that a substantially larger percentage of aircraft land and require unscheduled

maintenance than is reported by flying units. Possible reasons for these discrepancies (as discussed further in Vol. I) could include (1) the observed (but poorly understood) tendency for aircraft breakrates to be reduced at higher sortie rates, (2) an apparent tendency for LCOM data to reflect a conservative view of what must be repaired for an effective combat sortie, and (3) the strong possibility that the occurrences of unscheduled maintenance tasks are correlated—i.e., should not be treated as independent events. The entry in the fifth field specifies a value for the total "percent of aircraft that land with deferrable or nondeferrable unscheduled maintenance," excluding battle damage repairs (i.e., aircraft that have Code 2 or Code 3 "breaks"). When a value is entered, that percent of the aircraft is selected at random in subroutine CKMAIN, and only those aircraft so selected will incur unscheduled maintenance; the likelihood that unscheduled maintenance is required in each shop is increased in the proportion necessary so that the total amount of work required for a large number of sorties will be the same as when the tasks are treated as independent. The division of unscheduled maintenance between Code 2 and Code 3 is based on the several TSAR mechanisms for specifying task criticality and deferrability.

The last ten entries on a CT15/3 card provide the user with the means of specifying collections of mission-dependent battle damage tasks; if such tasks are specified for any mission, they override whatever battle damage task collection was specified on the CT15/2 card. As noted above, each of the tasks in these task collections are checked for damaged aircraft at that point in the shop-task sequence (CT29) where Task #30000 has been specified.

The CT15/4 card permits the user to specify the times at which phased maintenance should be done on different types of aircraft. The user may specify up to ten frequencies and the numbers of the corresponding task networks; the entries *must* be ordered by increasing times between maintenance. When a more frequent inspection falls at the same time as a less frequent inspection, only the latter is performed.

The first entry on CT15/5 is the task number for an early morning preflight inspection that may be imposed on specific aircraft types at specific airbases (see CT17/3). The next five entries are task numbers for the (up to five) mission-dependent postflight inspections that will be imposed when Shop #25 is encountered in the CT29 shop-task sequence at airbases designated on a CT17/3 card.

If "Check Flight" is set to "1" in column 45, the requirements for check flights following completion of the maintenance tasks specified with the CT15/88 cards will be checked for this type of aircraft. Columns 46–50 are reserved for a switch to indicate that vertical landing is possible for this aircraft type; this feature is not yet implemented in the model.

Sample Data

Because a Type #2 mission is designated as the air-to-air mission for Type #1 aircraft on CT15/3, the effectiveness proxy results will be collected separately for mission #2. The next two entries on CT15/3 define the task numbers for hot-pit refueling and for a decontamination task required if there is any residual chemical contamination when an aircraft lands. Since there is no entry for the "Controlled Break Rate" in column 30, the occurrence of unscheduled maintenance tasks will be treated as independent events. The last entries on CT15/3 specify that aircraft damaged while on a Type #2 mission select the battle damage tasks from the task set #103 through #106; this set may be distinct from that specified on CT15/2, or may overlap that set as shown here.

These CT15/4 cards specify phased inspection tasks at every 50, 150, 300, and 600 hours of aircraft flight time; Task #201 every 50 hours, Task #202 every 150 hours, etc. At initialization, a time is selected at random in the interval 0 to 600 hours (i.e., the least frequent inspection time) for each Type #1 aircraft to define that aircraft's flight time. Whenever the aircraft's cumulative flight time exceeds any of the inspection thresholds (and DOPHAS = 1), the required work is carried out the next night. At 300 hours, for example, Task #203 is required (but not the 50-hour or 150-hour tasks) and at 350 hours, the 50-hour task, etc.

The CT15/5 card designates the early morning inspection as Task #53; this task will be imposed on Type #1 aircraft at each base that has had a time for this inspection defined on CT17/3. This card also specifies that a special postflight inspection is to be performed whenever a Type #1 aircraft completes mission #1 (Task #205) or mission #3 (Task #206).

Card Type #15/88

			Tasks for which check flights may be required													
Card Type		AC Type	Task	Prob. not Req'd	Task	Prob. not Req'd	Task	Prob. not Req'd	Task	Prob. not Req'd	Task	Prob. not Req'd	Task	Prob. not Req'd	Task	Prob. not Req'd
15	88	1	2		7	8000										
				10000=1.0												

The CT15/88 card specifies which aircraft maintenance actions require check flights on completion in order to test the adequacy of the work. The numbers of the simple tasks and the task-network root-segments that may require such check flights, and the probability (x10000) that a check flight is *not* required when these tasks are scheduled, are entered on these cards. Requirements can be specified for the unscheduled maintenance networks entered with CT7 cards and those entered on CT29 cards; they may also be specified for any of the battle damage task networks entered on CT15/2 and CT15/3. This check-flight option will *not* function for any task elements in a task network other than the root segment. These features are activated for those aircraft types for which a "1" has been entered for the control variable in column 45 on CT15/5.

This feature is implemented as follows: After an aircraft has landed and an initial determination of the next mission has been made, the tasks are divided between "deferrable" and "required before the next combat sortie"; the required tasks are then checked as to whether a check flight will be required when that maintenance has been completed. If a flight will be required, a special aircraft flag is set. Subsequently, as aircraft maintenance is carried out, munitions tasks are omitted. When all other required maintenance is complete, if an aircrew is available to fly the aircraft, and the runway is open, etc., the aircraft is flown (for 45 minutes). If the aircraft cannot be flown at that time due to lack of aircrew or an open runway, etc., it waits until conditions permit the flight. If a check flight is required when a previously deferred task is carried out, any munitions that have already been loaded are first downloaded. When the check flight is accomplished, additional unscheduled maintenance may be generated according to the same probabilities that govern return from a sortie (except ABDR); if it isn't, the aircraft is refueled and loaded with the appropriate munitions and is ready for a combat mission.

For aircraft that must be moved for maintenance to another airbase (either a host base for DOB aircraft, or a rear maintenance base) the test flight is flown from the

airbase where the task that required the flight was carried out. For check flights on aircraft that are to be transferred to another base, no additional maintenance is generated by the check flight.

Sample Data

The sample data for CT15/88 indicate that check flights may be required when Tasks #2 and #7 are carried out on a Type #1 aircraft; a check flight is always required following Task #2, and 20 percent of the time following Task #7 (i.e., 80 percent chance not required).

Card Type #16

AIRCRAFT MISSION DATA — ACMDTA ARRAY —

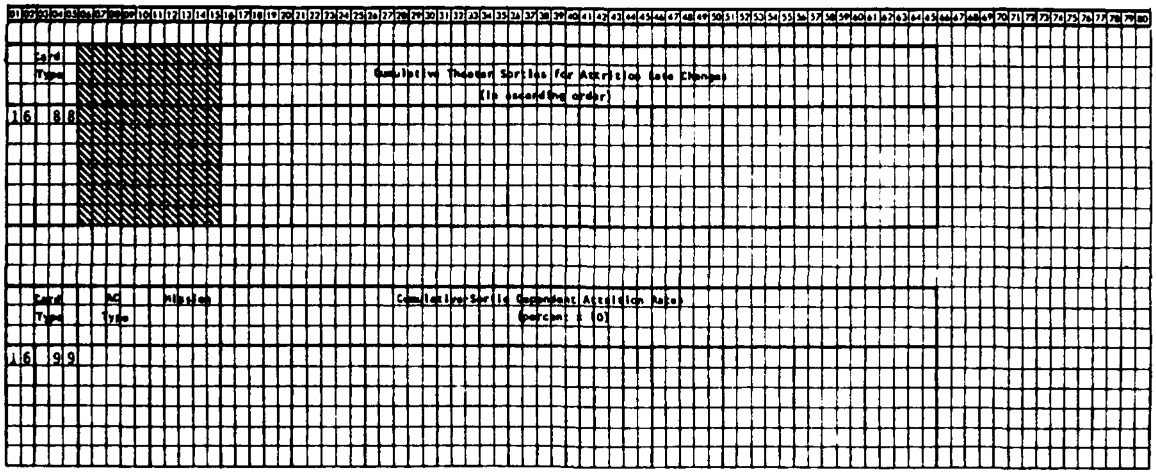
Card Type	AC Type	Mission	Extra Brief Time Min	Flight Time Mean Min	Dist	Max Orbit Time (Min)	Percent Aircraft Not Reparable	Aircraft Damage to Kill Ratio	Late Takeoff Allowance (Min)	Percent Abort * 10	Percent Crews Lost per AC Lost	Percent Armament Retained: Mission Dependent (Shop 28)	Percent Armament Retained: Basic (Shop 29)	Time Dependent Attrition Rate: ≤Day	Rate	≤Day	Rate	≤Day	Rate	≤Day	Rate	≤Day	Rate	Unit Landing if Unity
16	1	1	30	60		30	8	35	15	10	80	20	60	2	55	4	42	8	26	60	12			

The only flight data used in TSAR are entered here. For each aircraft type and each of the missions that the aircraft can fly, estimates are entered for the length of any special crew briefings and for the flight time. If aircraft of this type and mission are permitted to take off late, that allowance is also entered; the length of time that an aircraft may orbit after it returns from its mission but before it must land is also entered. These last two estimates are used with the air traffic control logic in deciding whether the runway will be available to launch and recover a flight. This card also provides for inputs that define the expected attrition and battle damage, air abort rate, and munitions expenditures; different attrition levels may be specified for each of five blocks of time. Members of a flight must recover together when air traffic control features are exercised. When these features are not exercised, members of a flight will recover independently unless a 1 is entered in the final field, in which case they recover together.

Sample Data

This card image indicates that the nominal flight time for mission Type #1 with aircraft Type #1 is one hour, and that 30 minutes of additional ground time are required for flight briefings; takeoffs up to 15 minutes after the scheduled flight time are acceptable, and aircraft are able to loiter up to 30 minutes when they return before landing. The aircraft abort 1 percent of the time on takeoff, 20 percent return with their mission-dependent munitions, and 60 percent retain their basic munitions. For the first two days, 5.5 percent of the aircraft are lost for each combat sortie; 4.2 percent are lost on the third and fourth days, 2.6 percent on the fifth through eighth days, and 1.2 percent thereafter. Three and one-half times as many aircraft are damaged in combat as are lost, and 8 percent of the aircraft damaged in combat are not reparable. As noted on CT15/2, 40 percent of the parts, selected at random, are recovered from the aircraft so badly damaged in combat that they are not reparable. When an aircraft is lost in combat only 20 percent of the aircrews are recovered.

Card Types #16/88 and #16/99



It is possible to vary the attrition for particular aircraft types and missions as a function of the cumulative sorties flown by all aircraft types from all bases during the simulation, rather than as a function of time. This option may be selected for only certain aircraft and missions; the attrition rates for all other aircraft and missions will still be controlled by the entries in columns 51–75 of the "regular" CT16 cards. This option uses the CT16/88 and CT16/99 cards. CT16/88 is used to specify up to ten cumulative theater sortie values at which attrition rates are to be changed; these ten values must be entered in monotonically increasing order into fields 3 through 12.

A CT16/99 card is then entered for each aircraft type and mission for which the attrition rate is to be a function of the total sorties in the theater. The attrition rates (percent times 10) are entered in fields 3 through 12 (the rates may not exceed 49.9 percent); these rates are applied until the total sorties flown in the theater equals the number in the corresponding field on the CT16/88 card. If a CT16/99 card is entered for which the aircraft type and/or the mission type is not specified, the attrition rates specified on that card will be assigned to all aircraft types and/or all missions, respectively. If most aircraft and missions are to have the same attrition rates, but some are to be different, the rates for those with the common rates should be entered first, using a CT16/99 card without aircraft type or mission specified; this card should be followed by the CT16/99 cards for those aircraft and missions that are to be different (these latter values will override the common values entered first). The damage-to-kill ratio for each aircraft type and mission are controlled by the entry on the relevant CT16 for both options.

MISCELLANEOUS AIRBASE DATA

Card Type #17/1

MISCELLANEOUS BASE DATA

Card Type	Base No.	Host Base	Base Kind	Enter 1 if base is 66-1 & data are COMO	Cross-trained Personnel	Task-assist qualified Personnel	Weapon Assembly Tasks	Number Shelters	Aircraft per Shelter (x10)	Alert Shelters	POL Capacity	Equip No.	AC To	Fuel Truck Refill Time (Min)	Taxi Time (min)	Time to Shelter extra AC (min)	Relocate logical state
17	1	1	1		1		4	24	10		428000	80	4	60	12	0	1

Miscellaneous base data are entered on the various CT17 cards. On the first of the several subtypes, CT17/1, the kind of base is entered in the columns 14–15; 1 denotes a MOB, 2 a COB, and 3 a DOB. For a DOB, the "Host" base must be specified in columns 11–13. A 1 should be entered in the next field if maintenance personnel at the base are in a wing-level (66–1) maintenance organization, and the task data have been prepared for a squadron-level COMO (66–5) organization; this entry signals the program to ignore the backshop personnel number, and use the equivalent flight-line specialist for the parts repair procedures. The same entry also signals the program to extend the mean on-equipment task times by NOPOMO time units (CT4/2), to account for the increased dispatch and travel time in a 66-1 type of organization.

If the maintenance personnel at the base have been cross-trained for certain tasks or have been qualified to assist on various tasks, a 1 should be entered as appropriate in the next two fields. The entry in columns 31–35 is used to control the assignment of weapons assembly personnel in Shop #30 after all munitions demands for all announced flights (see CT50) have been satisfied; additional assembly tasks are defined and initiated until the number of ongoing tasks equals the value entered.

The number of aircraft shelters is specified in columns 36–40. The average number of aircraft that may be housed in each shelter (times 10) is entered in columns 41–45. The number of shelters to be allocated preferentially to special alert aircraft is entered in columns 46–50; damage to these shelters and their contents will be distinguished from damage to the other shelters.

The next entry is the base's POL storage capacity; that capacity should be expressed in the same units used for specifying POL supplies (CT27) and the aircraft's per-sortie consumption (CT15/1); thousands of pounds is often used. Since this value cannot exceed 32750, it may be necessary to select a different unit of measure—tons, for

The next two fields permit aircraft refueling using fuel trucks to be simulated more carefully than is otherwise possible. The equipment number that is used for fuel trucks is entered in columns 56–58, and the number of aircraft that can be refueled by a full fuel truck is entered in columns 59–60. The time that a fuel truck will be unavailable when it has to be refilled is entered in columns 61–65. When these entries are provided, up to 40 fuel trucks will be loaded at each base at initialization, and records will be maintained throughout the simulation as to which trucks have how many fuel loads remaining. When a truck is empty, it remains unavailable for the time needed to be refilled.

The average time required for an aircraft to taxi from touchdown to its shelter (or hot pit) and from the shelter to the takeoff can be entered in columns 66–70. The aircraft will be exposed to damage appropriate for "aircraft in the open" while it is taxiing if an air attack occurs during that time. When aircraft are to be launched, and a taxi time has been specified, maintenance must be complete sufficiently ahead of scheduled takeoff time that the aircraft can taxi into position.

The meteorological condition assumed to apply at the base is entered in the last field of CT17/1; the entry (if not null) must be one of the meteorological conditions entered with CT43/2. If USECW (CT3/4) is initialized so that the effects of wearing chemical ensembles is simulated, this variable may not be null.

Sample Data

The sample data indicate that Base #1 is a MOB and has cross-trained personnel. At least four munitions assembly tasks are to be ongoing at all times, if resources permit. The base has 24 shelters, and an average of 1.0 aircraft may be housed in each shelter; four of the shelters will be set aside for alert aircraft. POL storage capacity is 28000 units. Fuel trucks are identified as Type #80 AGE, and each can refuel four aircraft; it takes 60 minutes to refill a fuel truck. On the average, aircraft will take 12 minutes from the time they touch down and are at their shelter and 12 minutes from the time they begin to taxi until they launch. The meteorological conditions at Base #1 at the beginning of the simulation are those defined as state #1; they may be changed, subsequently, using a CT49 change card.

Card Type #17/2

			TASK TIME MODIFIERS														
Card Type	Base No.	HURRY (percent) On Equip	Pre-Flight	Off Equipment	Munitions Assembly	Civil Engineering	REDUCE (min) On Equipment	Pre-Flight	Off Equipment	Munitions Assembly	Civil Engineering	SAVE (min) On Equipment	Pre-Flight	Off Equipment	Munitions Assembly	Civil Engineering	
17 2	1	100	80	100	100	100	0	0	0	0	0	0	0	0	0	0	
	2	100	100	130	100	100	0	0	0	0	0	0	0	0	0	0	

Task times may be modified to reflect various schemes of work speedup. The HURRY, REDUCE, and SAVE arrays control these modifications according to the relationship:

$$\text{Task Time} = \text{HURRY(i)/100)} \times D_j\,[\text{Mean Time} - \text{REDUC(i)}] - \text{SAVE(i)}$$

where D_j represents the value selected in subroutine TTIME from the task time distribution j, and

i = 1 for on-equipment tasks (CT5 and CT6)
= 2 for preflight tasks (CT13 and CT14)
= 3 for parts and equipment repair jobs (CT8, CT9, and CT10)
= 4 for munitions assembly jobs (CT11)
= 5 for civil engineering tasks (CT38)

HURRY Percent of nominal task time
REDUCE Mean time reduction in minutes
SAVE Overall task time reduction in minutes

These procedures may be used to modify the many input values on CT5, CT6, CT8, CT9, CT10, CT11, CT13, CT14, and CT38, by entering values for HURRY, REDUCE, and SAVE with CT17/2. Different values may be specified for each of the five groups of tasks at each base. If no base number is entered, the values will be the same at all bases. When these values differ from the default values of 100, 0, and 0, task times are computed as shown above.

Sample Data

CT17/2 indicates that preflight tasks are to be done in 80 percent of the nominal times at Base #1; all other tasks are to be done in the times that have been specified. At Base #2, equipment repairs are to take 30 percent more than the normal time.

Card Types #17/3, #17/4, #17/5, and #17/6

- NODES ARRAY -

Card Type	Card No.	Base	Number Nodes	Number Arcs	Number Ramps	Number of Squadrons	CRBLDG	Shelter Priority	AM Inspection Hr	AM Inspection Min	Type Ensemble	Override NOMINL	Hot Pit Area Sqd 1	Hot Pit Area Sqd 2	Hot Pit Area Sqd 3
17	3	1	42	45	2	2	125	0	4	30	1	0	20	43	

- ARC ARRAY -

Card Type	Card No.	Base	Arc Data Number	Arc Data Node	Arc Data Node	Arc Data Length (100s)	Arc Data Number	Arc Data Node	Arc Data Node	Arc Data Length (100s)	Arc Data Number	Arc Data Node	Arc Data Node	Arc Data Length (100s)
17	4	1	1	1	2	13	2	2	3	10	3	3	4	10
17	4	1	25	22	24	4	26	24	25	2	27	24	26	4

- SHELT ARRAY -

Card Type	Card No.	Base	Number Ith Shelter	Nodal Number at Shelter Location I	I+1	I+2	I+3	I+4	I+5	I+6	I+7	I+8	I+9
17	5	1	1	20	20	23	23	25	25	28	28	29	29

- RWYARC ARRAY -

Card Type	Card No.	Base	Runway Number	Arc Numbers that Comprise Runway—Start From most Westerly End of Runway					
17	6	1	1	1	2	3	4	5	6

These cards permit the user to define a taxiway network and its relationship to the various shelters and runways at each airbase, as well as other airbase-related data. CT17/3 defines the total numbers of nodes and arcs that compose the taxiway network, as well as the number of aircraft parking ramps at each airbase, the number of squadrons in the wing with the largest number of squadrons, and the number of the CRBLDG for the base. The CRBLDG affects civil engineering facility repair prioritization; if resources are sufficient to initiate repairs on all damaged buildings up to and including this building on the priority list (CT39), the primary repair procedures are used; otherwise, secondary procedures are selected. If a 1 is entered in columns 46–50 on the CT17/3 card, the Type #1 aircraft shelters will be assigned in preference to the other shelter types, and Type #2 shelters will be assigned in preference to Type #3.

The user may impose a scheduled inspection early in the morning before the start of the flying day by specifying the morning inspection task number on CT15/5 and by specifying the time at which such an inspection should be initiated at particular airbases in columns 51–55 of the CT17/3 card (midnight must be designated as 24:00 not as 0:00). The entry in column 60 on the CT17/3 card designates which type of chemical ensemble is used at each airbase.

Normally, the AIS repair capability at an airbase is located in a single building; CT35/3 allows the user to designate which parts are repaired using the AIS and thus may only be repaired in the parent of a distributed shop. If a 1 is entered in columns 61–65 on CT17/3 to designate that the stations of an AIS facility have themselves been distributed to various locations at a particular airbase, the CT35/3 entries will be ignored for that airbase.

CT17/3 is also used to locate the hot-pit refueling area for each squadron; the arc numbers corresponding to the hydrant location for squadrons #1, #2, and #3 are entered in the 13th, 14th, and 15th data fields. Aircraft that are hot-pit refueling at the time of an air attack are assumed to be at these locations. (If equipment equivalents are not specified for hot-pit hydrants with CT46, all aircraft hot-pit refueling will occur at the arc in the 13th field.)

The ends of each taxiway segment are defined as nodes, and each taxiway segment is referred to as an arc. Both ends of each taxiway segment must be defined as nodes, including those that provide entry to an aircraft shelter. The user obtains the arc and node numbers by making a map of the base and numbering each of the arcs and nodes. The taxiway segments *must be numbered* in the same order in which they are entered into the TSARINA target data file so that the hits and chemical contamination computed in TSARINA for a particular segment will be associated with the same segment in TSAR.

The CT17/4 card defines the structure of the taxiway network for TSAR. The data entered are the arc number for each segment, the node numbers at each end of the arc, and the length of the taxiway arc (in hundreds of feet).

CT17/5 designates the number of the node at which each aircraft shelter is located. The shelters must be *numbered in the same order* in which they are entered in the TSARINA input data file.

One CT17/6 is required for each of the surfaces that is a runway, or can be used as an emergency runway during wartime. The data that are entered for each runway are the numbers of the several arcs that constitute that runway. The arc numbers are entered in order from the most westerly end of the runway. The purpose of these data is to permit the location selected in TSAR for runway repairs to be located in relation to the taxiway network; when the section of runway to be cleared is identified, the model is able to determine what fraction of the aircraft shelters are able to access the runway section that

is being cleared. The runway arc structure is also used to subdivide and manage runway clearance repair activities. All UXO are cleared on a runway arc before mine clearance is begun, and mines are cleared before craters are repaired; for this reason, each runway arc should generally be no longer than 500 to 1000 feet, if the several steps needed for runway restoration are to be managed efficiently.

Sample Data

Base #1 is defined (on the CT17/3 card) as having a taxiway system with 42 nodes and 45 arcs (taxiway segments). There are two aircraft parking ramps and two aircraft squadrons. The CRBLDG is facility #125. Early morning aircraft inspections are to be performed at 0430; personnel at Base #1 have Type #1 CW ensembles. The hot pits provided for refueling aircraft in squadrons #1 and #2 are located on arcs #20 and #43, respectively. The illustrative #17/4 data used to define the arc-node structure indicates that arc #1 lies between nodes #1 and #2 and is approximately 1000 feet long, and arc #26 lies between nodes #24 and #25 and is about 200 feet long. The CT17/5 specifies that the closest node to aircraft shelters #1 and #2 is node #20, the closest node to aircraft shelters #3 and #4 is node #23, etc. The CT17/6 card indicates that runway #1 at Base #1 is composed of arcs #1, #2, #3, #4, #5, and #6.

Card Types #17/7 and #17/8

RUNWAY AND TAXIWAY REPAIR CRITERIA

Card Type		Base No.	Runway Repair Mode	Extended MOS Length	Extended MOS Width	Number Surfaces	MCL (ft)	MCW (ft)	No Barrier Length	Skewed MOS	Maximum Skew (deg)	Limit Runway Extension	Unexploded Crater Weight
17	7	1	1	4000	75				3999	2			

(These inputs override TSARINA)

AIRCRAFT PARKING RAMP CHARACTERISTICS

Card Type		Base No.	Type 1 & 2	Card No. (1 or 2)	1 or 11	2 or 12	3 or 13	4 or 14	5 or 15	6 or 16	7 or 17	8 or 18	9 or 19	10 or 20
17	8	1	1	1	60	40								
17	8	1	2	1	13	14								

Type #1: Relative Parking Capacity Type #2: Adjacent Node

CT17/7 provides the user with options for extending the MOS after it has been cleared. The value of the runway repair mode (RRM) entered in the second data field controls how this additional repair work is managed (see Sec. VIII.5 for a complete discussion of the MOS extension options provided by the several values allowable for RRM). The third and fourth data fields contain the length and width for the extended MOS as required for nonzero values of RRM. If a "1" is entered in the eleventh field, runway repair will not continue after the "Extended MOS" is cleared, independent of the "Runway Repair Mode." The fifth data field provides the user an option for controlling the number of runways to be examined in selecting the MOS (a value of N in the field limits the MOS selection to the first N runways). Nonzero entries in the sixth and seventh fields replace the values of minimum clear length (MCL) and minimum clear width (MCW) input from TSARINA.

The "No Barrier Length" entry in the eighth field permits the user to increase the times for recovering aircraft when a mobile arresting barrier must be used with the MOS. When any value is entered in this field, it is presumed that a mobile aircraft arresting system (MAAS) must be employed when the available surface length is no greater than this entry; facility #49 is synthetically "damaged" and aircraft launch and recovery times are degraded consistent with the entries for facility #49 on CT17/11. When and if the clear length is extended beyond this length, facility #49 is "repaired." When this feature is in use, facility #49 may not be at risk in TSARINA.

The "skewed MOS" entries in the ninth and tenth fields of the CT17/7 card permits the user to specify that the MOS need not be parallel to the sides of the runway at specified bases. When the integer N is entered in the ninth field, each operating surface

will be checked for an MOS that is skewed by multiples of N/4 degrees from parallel. Thus, if 1 is specified, MOS at 0.75, 0.50, 0.25, 0, –0.25, –0.50, and –0.75 degrees relative to parallel would, for example, each be checked for repairs. If M is entered in the tenth field, the maximum skew angle that will be checked is M/4 degrees from parallel with the sides of the surface. When the same number of craters are required for two locations that are skewed different amounts, the least skewed is selected. This feature is not operative for surfaces that are narrower than 3/2 the MCW.

CT17/8 specifies the relative capacities of the various aircraft parking ramps. These capacities are used to select where unsheltered aircraft are to be parked when sufficient aircraft shelters are not available. Relative capacity data and the number of an adjacent node should be entered for each ramp on each airbase at which aircraft would be parked in this situation; the order of these data *must correspond* to the order in which the parking ramps are entered in the TSARINA target data base.

Sample Data

The 1 in the field for the RRM indicates that after the MOS has been cleared, an MOS should be cleared on the main runway if the original MOS is not on the main runway; then the main runway MOS should be lengthened to 4000 ft (the length of the extended MOS is shown in columns 16–20), and then widened to 75 ft (the width of the extended MOS is shown columns 21–25), and then the main runway is to be cleared entirely (see Sec. VIII.5). (If a 1 had been entered in column 60, clearance would be stopped after the extended MOS had been completed.) The absence of entries in columns 26–40 indicates that the data transferred from TSARINA to TSAR should be used in selecting an MOS. The "No Barrier Length" of 3999 ft in columns 41–45 assures that the CT17/11 degradations for a damaged facility #49 will be imposed until the operating surface has been extended to 4000 ft.

The CT17/8 cards indicate that 60 percent of the unsheltered aircraft are to be parked on ramp #1 and 40 percent on ramp #2; the closest node to ramp #1 is node #13 and the closest to ramp #2 is node #14.

Card Types #17/9 and #17/10

Card Type		Base No.	Post-Attack Delays: Earliest Takeoff (Min)	Post-Attack Delays: Maintenance (Min)	Post-Attack Delays: Facility Repair (Min)	Time to Survey, etc. Prior to RRR (Min)	Aircraft Types Not to Occupy Shelters			Off-duty air-crew facilities	Aircraft Replacement: Surv. %	Aircraft Replacement: HR	Evacuate Aircraft: HR1	Evacuate Aircraft: HR2	Trap AC in HAS: HR1	Trap AC in HAS: HR2	Shelter Types w/o Doors: 1	Shelter Types w/o Doors: 2	Shelter Types w/o Doors: 3	HAS Repair Limit (percent)	Aircraft Decontamination Switch
17	9	1	10	60	120	20	0			1											0

Card Type		Base No.	Control for Variable Damage to "All Other" Items: Personnel	Equipment	Spares	Munitions	TRAP	Building Material
17	10	1	0	0	60	0	0	0

CT17/9 is used to enter additional base-related data. The second data field entry is the minimum time (in minutes) after an air attack that aircraft are permitted to land or take off. The third and fourth data fields are for additional postattack delays (also entered in minutes) that are imposed before any maintenance activity can be reinitiated and before civil engineering facility repair activities may be started; these delays are an addition to SHPDLY and CEDELY (see CT4/1). These additional postattack delays are only operative for damage data generated by TSARINA; when the "40" cards have been prepared in some other way, only SHPDLY and CEDELY are taken into account. The value in the fifth data field is the time (in minutes) required for the survey, UXO removal, mine clearance, and whatever other work must be accomplished before the runway repair simulation can be started; when UXO and mine removal are simulated explicitly, only the time required to select the MOS location should be entered.

Since these delays could vary widely for the various types of attacks that a base might be subjected to, each of the values can be changed as the simulation progresses, using the Type #26 change with CT49.

The aircraft type numbers for up to three aircraft types that will not fit into the available aircraft shelters at a particular airbase can be entered in the sixth, seventh, and eighth data fields of CT17/9. If the aircrews that are not on duty are to be assumed to be at rest in a different set of facilities than those who are on duty, enter a 1 in the ninth field. The last entry on CT17/9 permits the user to require that aircraft be decontaminated upon landing even when there is no on-base chemical contamination. If the last entry is not null or zero, this task will be required. Change Type #28 (CT49) permits this switch to be reset after the simulation starts.

The CT17/10 card controls a feature that permits the user to distribute losses sustained from the *conventional* effects of air attack nonuniformly among the "all other" categories[4] of each resource class. When the entry is 100, all items of the same type are treated as though they were all located together, and either all are destroyed or all survive; when the entry is 0, all items of the same type are assumed to be dispersed uniformly among the various locations, and all types sustain the same percentage loss.

When the entry (control variable VARPK—variable PK) is initialized between 1 and 100, the distribution of losses among all other resource types is computed as follows. Let PCT be the percent loss rate computed in TSARINA for resource type #0 (i.e., "all other"). Then PCT percent of the resource types in the "all other" category will sustain a loss rate PH ≥ PCT, and the remaining resource types will sustain a loss rate PL ≤ PCT. PH and PL have the property that when VARPK is 0, all resource types suffer a PCT loss rate (i.e., PH = PL = PCT); when VARPK is 100, PCT percent of the resource types are lost entirely, and none of the other types are lost (i.e., PH = 100 and PL = 0). For intermediate values of VARPK, PH and PL are defined as:

$$PH = ((100 - VARPK) \times PCT + 100 \times VARPK)/100$$
$$PL = (100 - VARPK) \times PCT/100$$

Thus, the expected number of resources lost is the same for all values of VARPK, but the distribution of those losses across resource types depends on VARPK. The effect of the variable NONUNI is unchanged with this feature. This feature does not affect the distribution of losses and casualties caused by chemical attacks, only the losses from conventional attacks.

Sample Data

The CT17/9 indicates that no aircraft are to use the runway for at least 10 minutes after an air attack and that all on- and off-equipment maintenance and munitions assembly tasks will be delayed for 60 minutes after an attack. No civil engineering repair work can start until two hours after the attack, except repair to the runway-taxiway system, which can begin 20 minutes after the attack. The entry in column 50 specifies that off-duty aircrews will be located in different facilities than the on-duty aircrews.

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[4]The "all other" label is a user convenience to avoid entering locations for the many individual items in the TSARINA input data stream.

The 60 entered in columns 21–25 on CT17/10 indicates that losses to the "all other" category of spare parts are to be assigned nonuniformly to those types of parts, representing a situation in which these part types are not distributed uniformly throughout their storage locations.

Card Type #17/11

AIR TRAFFIC CONTROL MINIMUM SEPARATION TIMES

Card Type		Base No.	Card No.*	Takeoff Times (sec)** Aircraft to Aircraft	Flight to Flight	T.O. Flt to Lnd Flt	Landing Times (sec)** Aircraft to Aircraft	Flight to Flight	Lnd Flt to T.O. Flt
17	11	1	1	10	60	90	20	60	90
17	11	1	2	10	-50	-50	20	-50	-50
17	11	1	7	150	180	180	150	180	180

*1 Enter value appropriate for fully operational base.
Degradations:
2 When main runway is not in use
3 When surface in use has residual craters
4 When Facility #46 is damaged
5 When Facility #47 is damaged
6 When Facility #48 is damaged
7 When Facility #49 is damaged

**Positive entries on Card #2 through #7 are interpreted as increases (in seconds) in the basic times on Card #1 when the corresponding conditions are satisfied; the absolute value of a negative entry is interpreted as a percentage increase in the basic time.

CT17/11 is used to enter the data needed when the constraints imposed by air traffic control requirements are to be simulated. There are two modes of operation; the mode used is determined by the value of DOATC (CT1). When DOATC is 1 or 2, the MODE is I; for DOATC of 11 or 12, the MODE is II. For MODE I as many as seven CT17/11 cards may be entered for each base. Card number 1 provides the minimum permissible values for six aircraft launch and recovery separation times when the base is fully operational. The times that are entered, in seconds, are for (1) the times between aircraft within a flight that is being launched, and within a flight that is being recovered, and (2) the times between the last aircraft of one flight and the first of the next flight when both flights are launching, when both flights are recovering, and when one flight is doing each.

The other six cards provide information as to how the six separation times, which apply to a fully operational base, are degraded for various types of base damage. A positive entry on any of these last six cards is interpreted as the number of seconds that must be added to the basic time, if the relevant base damage exists; for a negative entry, the absolute value is interpreted as a percentage increase in the basic time. Null entries (or zeros) imply no degradation.

The degradation conditions are defined as follows:

Card Number	Condition for Applying Degradation
2	Main runway is not in use
3	Surface with MOS has residual craters

4	Facility #46 is damaged
5	Facility #47 is damaged
6	Facility #48 is damaged
7	Facility #49 is damaged

The main runway is defined as runway #1 entered with CT17/6.

If several of these conditions apply, the degradation of the air traffic control separation times is determined by combining the individual degradations. As noted for CT17/7, the degradations associated with facility #49 are automatically imposed when the "No Barrier Length" field on CT17/7 is initialized and when the aircraft launch and recovery surface that has been cleared is no longer than that length.

For MODE II, up to 21 cards may be entered for each base. Seven different cards may be entered for each of (1) the main runway, (2) the main taxiway, and (3) all secondary taxiways. The first card for each surface defines the minimum permissible values for the six aircraft launch and recovery separation times when the surface is fully clear, and no ATC aids (i.e., facilities #46 through #49) are damaged. The second set of cards defines the degradations to these minimums when only an MOS is available on the surface; the third set expresses the degradations when there is more than an MOS but there are still craters on the surface. The last four sets of cards for each surface define the degradation factors that are applied when there is damage to the four special facilities #46, #47, #48, and #49. The interpretation of the card entries for MODE II is identical to that for MODE I. If data are not supplied for secondary taxiways the factors specified for the main taxiway are used.

The several cards used with MODE II are defined as:

Card Number	Condition for Applying Degradation
	MAIN RUNWAY
1	Base is fully operational
2	Only an MOS is available
3	More than an MOS is available but craters remain
4	Facility #46 is damaged
5	Facility #47 is damaged

6	Facility #48 is damaged
7	Facility #49 is damaged
	MAIN TAXIWAY
8	Base is fully operational, except main runway
9	Only an MOS is available
10	More than an MOS is available but craters remain
11	Facility #46 is damaged
12	Facility #47 is damaged
13	Facility #48 is damaged
14	Facility #49 is damaged
	SECONDARY TAXIWAYS
15	Base is fully operational, except main runway and main taxiway
16	Only an MOS is available
17	More than an MOS is available but craters remain
18	Facility #46 is damaged
19	Facility #47 is damaged
20	Facility #48 is damaged
21	Facility #49 is damaged

Sample Data

The sample CT17/11 cards illustrated here apply for MODE I. The first card specifies that aircraft in a flight can take off at 10-second intervals and land at 20-second intervals when Base #1's ATC capabilities are not degraded. There must be only 60 seconds between two flights that are both landing or are both taking off, and 90 seconds between a flight that is landing and one that is taking off (or vice versa). The second CT17/11 card shown specifies that when the main runway (runway #1) cannot be used, an additional 10 seconds is required between aircraft in a flight that is taking off, and an additional 20 seconds is required between aircraft in a flight that is landing. The times between flights must all be increased 50 percent when the main runway is not used. When a MAAS is in use (i.e., when facility #49 is "damaged"), the degradations on the third sample CT17/11 card are imposed: an additional 2.5 minutes between aircraft in a

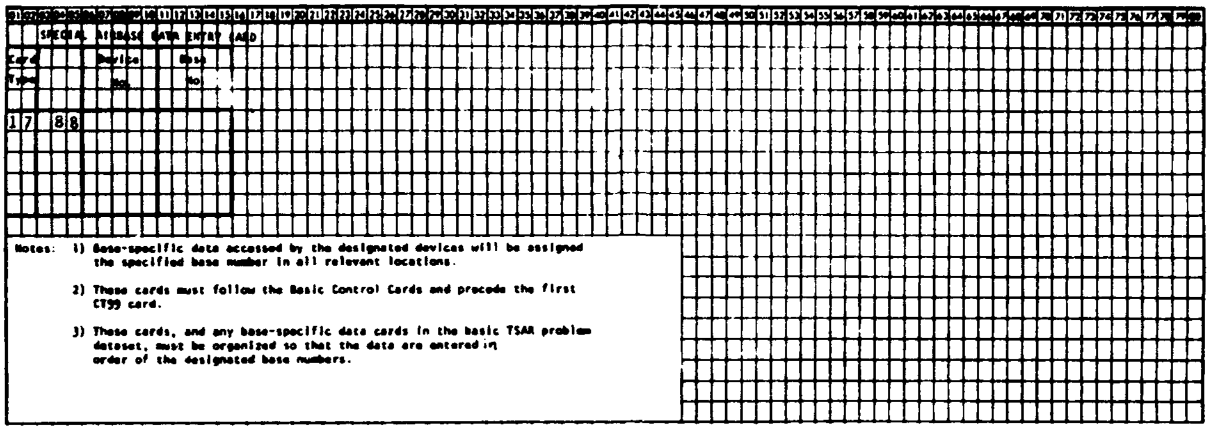
flight and an additional 3 minutes between flights. (The CT17/7 example given above implies that the MAAS would be used whenever the cleared surface is not greater than 3999 feet.)

Card Type #17/12

Card Type	Base No.	AIRCRAFT TYPES FOR WHICH DEFERRED MAINTENANCE IS PROHIBITED
17	12	

When a particular type of aircraft is diverted due to air attacks on its scheduled recovery base, it may have to recover on a base that cannot carry out all the normal maintenance for that type of aircraft. Since TSAR does not currently provide procedures by which needed personnel or equipment can be transported to that base (and then returned), it is sometimes necessary to neglect certain requirements in order that aircraft are not unrealistically stranded at a base. Most such activities may be ignored by not entering particular shops and tasks (including #30000 for ABDR) on CT29 for certain aircraft types at certain airbases. However, these tasks may still be required at bases that cannot handle them, when aircraft are checked for deferred maintenance at night. This card permits the user to designate the specific aircraft types that should not be checked for deferred maintenance on specific airbases; such requirements are further deferred until the aircraft is returned to a base not so designated.

Card Type #17/88



SPECIAL AIRBASE DATA ENTRY CARD

Card Type	Device No.	Base No.
17 88		

Notes: 1) Base-specific data accessed by the designated devices will be assigned the specified base number in all relevant locations.

2) These cards must follow the Basic Control Cards and precede the first CT99 card.

3) These cards, and any base-specific data cards in the basic TSAR problem dataset, must be organized so that the data are entered in order of the designated base numbers.

This card simplifies the introduction of data for several airbases. When descriptive data for several bases must be combined, the base number on many cards will normally need to be changed so that each base has a unique number. To simplify this task, the user can store the card images that describe each base separately and then use a CT17/88 card to recall the stored data for each base, enter the appropriate base number in all required locations, and then integrate these data with the other input data. The card types that may be stored in the dataset include CT17 (all types), CT20 through CT26, CT29, CT30, and CT36 through CT43. However, the CONUS shipments (CT31), transportation schedule cards (CT32), locations for NRTSing parts (CT34), and flight demands (CT50) may *not* be included; nor may the CT20/66, CT2x/88, CT22/66, CT23/76, or CT23/88 cards. Each CT17/88 must specify the DEVICE where the data have been stored and the base number that is to be assigned; subroutine BEDOWN is called when this card is read, and it reads in the data and modifies the base number in all required locations.

The only restrictions for using CT17/88 are that these cards must be entered after the basic control cards and before the CT99 card that precedes the CT50 cards, and they must be organized so that the base data are entered for the bases in numerical order; this last requirement is the same as that normally imposed for CT17 cards. The appropriate place to enter the CT17/88 cards is at the same location in the input deck where the regular CT17 cards would have been located.

Card Type #18/1

- BEGINNING OF DAY SHIFT AND PERCENTAGE OF AIRCRAFT EXPOSED -

Card Type	Card No.	Shop 1, 11, or 21 Hr	Pct	Shop 2, 12, or 22 Hr	Pct	Shop 3, 13, or 23 Hr	Pct	Shop 4, 14, or 24 Hr	Pct	Shop 5, 15, or 25 Hr	Pct	Shop 6, 16, or 26* Hr	Pct	Shop 7, 17, or 27 Hr	Pct	Shop 8, 18, or 28 Hr	Pct	Shop 9, 19, or 29 Hr	Pct	Shop 10, 20, or 30 Hr	Pct
18 1	1	8	30	8		8		8	20	8		8		8	20	8		8		8	
18 1	2	8		8		8		8		8		8		8		8		8		8	
18 1	3	8		8		8		8		6		6		4		4		6	60	2	

*Shift time for Shop #26 is used for civil engineers.

The CT18/1 cards specify the beginning of the "day" shift for each of the 30 shops and the fraction of the tasks for each of the shops for which the aircraft shelter door must be open (this exposes an aircraft to a higher likelihood of damage). The permissible entries for shift changes are limited to even-valued hours between zero (midnight) and ten (1000 hours); the two 12-hour shifts are presumed to be the same for the same-numbered shops at all bases. When an airbase is attacked, each sheltered aircraft is checked to see which shops are engaged in tasks on the aircraft; the requirement for an open shelter door is determined on a random basis.

Tasks associated with Shop #25 (the flight-line shop), and with the preflight shops (Shops #27, #28, and #29), are treated differently than other shops at the time of their shift change. These shops have a flexible overtime policy, which means that no ongoing tasks are interrupted as a result of the shift change. Instead, all ongoing tasks at shift change time are completed before the crew is released. The shift change times for Shops #26 and #30 are used for civil engineers and for munitions assembly personnel, respectively. If no CT18/1 are included, the default shift change time is midnight (equivalent to a null entry on CT18/1).

Sample Data

The day shift commences at 0400 for Shops #27 and #28, and at 0600 for Shops #25 and #29 and for the civil engineers; all others change shift at 0800, except for the munitions assembly personnel (Shop #30). The aircraft shelter door must be left open some percent of the time that Shops #1, #4, #7, and #29 work on an aircraft; this occurs 30 percent of the time for Shop #1, 20 percent for Shops #4 and #7, and 60 percent for Shop #29.

Card Type #18/2

BREAK RATE MODIFIERS (Input rates modified by indicated percentage or reduced by indicated percentage for each sortie/day/UE > 1, VBREAK = 1)

Card Type	AC Type	Card No.	SHOP 1, 11, or 21	2, 12, or 22	3, 13, or 23	4, 14, or 24	5, 15, or 25	6, 16, or 26	7, 17, or 27	8, 18, or 28	9, 19, or 29	10, 20, or 30
18 2	1	1	100	120	80	100	100	100	80	100	100	100
18 2	1	2	100	100	100	100	100	100	100	100	100	100
18 2	1	3	100	100	100	100	100					

The probabilities that the various unscheduled on-equipment maintenance tasks are required after a sortie are entered with CT7. The data available for estimating these probabilities, or breakrates, are usually derived from peacetime experiences at low sortie rates. However, the breakrates at higher wartime activity levels may be different on a per sortie basis. These cards permit the user to reflect such phenonoma in the simulation, on a shop-by-shop basis. The breakrates may be reduced or increased from the nominal values for whichever aircraft types and shops are designated. Two options are available. If the control variable VBREAK (CT3/2) is zero, the entry on CT18/2 is interpreted as the percent of the nominal breakrate (as entered with CT7) that should be used for the simulation. If VBREAK is unity, the entry is interpreted as the percent reduction in the breakrate that is experienced for each sortie/day/aircraft-on-base that the achieved sortie rate exceeds one. If no value is entered (100 percent of) the nominal values will apply.

Sample Data

These CT18/2 cards specify that unscheduled maintenance tasks are assumed to occur at the frequencies implied on the CT7 cards, except for those in the shop-task-collections for Shops #2, #3, and #7. For the latter two shops only 80 percent of the nominal breakrates are to be simulated, and for Shop #2 120 percent of the nominal breakrates is to be simulated.

Card Type #19

TASK INCOMPATIBILITY LIST - LISTIN ARRAY · 15 ENTRIES PER CARD

01–02	03–05	06–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70	71–75	76–80
Card Type	First Element No.															
19	61	6	7	-11	5	9	0	66	-1	7	7	-2	76	96	0	

All incompatible on-equipment task data are stored in the one-dimensional LISTIN array. If there are tasks that may not be initiated while other tasks are underway or until specific tasks have been completed, an entry on CT5 for such tasks specifies the first position in the LISTIN array for the relevant incompatibility data. Whenever an attempt is made to initiate such a task on an aircraft, all tasks being conducted on that aircraft are checked to see if they are incompatible. To ease the specification of incompatibilities, entire groups of shops and tasks and task segments may be specified as well as individual tasks.

At the position in the LISTIN array where incompatibility data for a given task begins (i.e., at the position indicated *in columns 52–55 on the* relevant CT5), there should first appear a list of the root segment task numbers of task networks that are incompatible with the given task. After this list of individual task networks has appeared, there are several shorthand options for specifying groups of incompatible activities. (Note that the list of individual task networks may be null; i.e., the data for incompatibility may begin with one of the following shorthand schemes.) If the given task may not be processed while one or more shops are working on the aircraft, the number –1 should be entered in the LISTIN array, followed by the first and last shop number (one or more shop number pairs may be listed in sequence). If the given task is incompatible with an entire block of task networks, the number –2 should be entered and followed by the first and last root segment task number in that block (several root segment number pairs may be entered for several incompatible blocks of task networks). If the task must not be started until *after* a set of task networks is completed, the number –3 should be entered, followed by the first and last root segment task number of each such set (several task segment pairs may be entered).

If only certain task elements are incompatible, the number –4 should be entered in the LISTIN array followed by the individual task element numbers. Finally, if there are

blocks of task elements (but not necessarily entire networks) that are incompatible, the number –5 should be entered followed by task number pairs that define the first and last task element in those blocks. A zero entry in the LISTIN array denotes the end of the list of incompatibilities for a particular task.

Sample Data

These data are filed in the 61st through 75th elements of the one-dimensional LISTIN array. Data in columns 6–30 specify those activities that may not be ongoing when Task #2 is to be initiated; the first two numbers refer to task networks #6 and #7. The number –1 signals that the following two numbers are the first and last shop of a range of shops that may not be active, thus Task #2 may not be started if either Shop #5, #6, #7, #8, or #9 is performing a task on the aircraft.

Data in columns 36–75 similarly specify that Task #6 may not be initiated if task network #66 or any job by Shop #7 is in progress; it may also not be started if any task in the range #76 through #96 is in process.

The first entry of an incompatibility list is specified on CT5 by naming the appropriate element in the one-dimensional LISTIN array; in this case, Task #6 specified element #67, because Task #66 is the 67th element. If some other task was incompatible only with task elements #76 through #96, the incompatibility pointer could specify #71, reusing a part of the Task #6 list, thereby saving storage space.

INITIAL STOCKS OF AIRBASE RESOURCES

The next eight types of cards (CT20 through CT27) define resource availability at zero time for each of the airbases. These data are required for each type of each of the eight resource classes that has been included in the user's descriptors of task requirements. These data may be entered separately for each base; or, if no base is specified (except for aircraft, crews, and POL), the same quantity of each class and type of resource is provided at each base. (When all but one base or only a few bases have the same quantity of a resource, the resource can first be entered for all bases with a zero base number and then changed for bases with a different quantity.) These data may also be stored as a separate dataset for each base along with other base specific data cards and incorporated into a TSAR input dataset with a single card image (see CT17/88) for each base.

Other aids are available for CT21, CT22, and CT23. When an "88" is encountered in the "J" field for any of these card types, two more entries are expected: #B1 and #B2. These entries designate that the entire stockage array for that class of resource is to be copied from Base #B1 into the storage space for Base #B2. If this card is placed at an intermediate point in the entries for Base #B1, only the data entered to that point are copied for Base #B2. A more sophisticated aid is available for parts data that automatically generates parts stocks and initializes the parts pipelines.

The quantities of all types of these various resources available in depots to replace losses may also be specified with the CT20 through CT27 cards. When a "99" is entered in the "J" field for any of these card types, the total numbers of resources of types I through I + 9 available at time zero are listed in the ten five-column fields in columns 11–60, where I is the resource type listed in columns 6–10 (see CT23/99). If any of the entries in these ten fields is zero *or null*, no depot stocks will be available to replace losses for that type of resource; when no CT2x/99 cards are entered for particular types of resources, depot stocks will be (essentially) unlimited.

With CT20/66, the user can direct the transfer of aircraft among airbases at specified times.

Card Type #20

AIRCRAFT ASSIGNMENT BY BASE

Card Type	Base No.	Aircraft Type	Sq	Number	Crews	Type	Sq	Number	Crews	Type	Sq	Number	Crews	Type	Sq	Number	Crews	Type	Sq	Number	Crews
20	1	1	2	24	30																
20	2	1	2	24	30																
20	77		1	12	120																
20	99		1	12																	
20	99	20	1	10																	

Card Type		Time Day	Time Hr	Bases From	Bases To	Aircraft Type	Aircraft Num	Freq Days	Mission*	Time Day	Time Hr	Bases From	Bases To	Aircraft Type	Aircraft Num	Freq Days	Mission*	Time Day	Time Hr	Bases From	Bases To	Aircraft Type	Aircraft Num	Freq Days	Mission*
20	66	1	3	1	3	1	4		1	3	18	3	1	1	4		0								
20	66	1	5	2	4	1	4		1	4	15	4	2	1	4		0								

*Designation of mission for aircraft is optional and is operative only at the host base.

Initial aircraft inve:.tories may include up to five different types of aircraft at each airbase. This card type is used to specify the initial inventory of each type of aircraft and the initial number of aircrews qualified for that type of aircraft at each base. The total number of aircraft in the simulation at any time is limited to the size of the ACN array (i.e., MAXACN), and the total number of aircrews is limited to the size of the PILOT array (i.e., NOCREW).

The CT41 and CT42 are used in conjunction with CT20 for initializing aircraft configurations for various missions and for initializing the status of aircraft maintenance. The CT41 card is mandatory, but the CT42 card is optional. These cards must be entered in numerical order, and both must be entered after CT20.

The aircraft of a given type at any particular base may be separated into two or three squadrons by entering a 2 or 3 in the "Sq" column. No more than three squadrons of each aircraft type may be simulated at an airbase. When more than one squadron is assigned, personnel and equipment may be assigned separately to each squadron, as in a 66–5 (COMO) type of organization, rather than having all aircraft draw upon a common group of such resources. Organization of those resources is controlled by the ALTPEO and ALTAGE arrays that are entered with CT45/1 and CT46.

The CT20/77 cards are used to initialize a pool of "filler" aircraft, if any, and to specify the time (in minutes) required to ferry the aircraft to the operating base when it has been assigned. The CT20/99 cards impose constraints on the number of aircraft of each type that are available in CONUS to replace losses incurred during flight operations or from airbase attacks. The availability and delivery delays for the CT20/99 replacement aircraft are controlled by CT33; these aircraft are in addition to those that

are designated for the filler force (CT20/77). Each filler aircraft and each replacement aircraft is ferried by an aircrew that is presumed to be reassigned to the operating unit on arrival.

The CT20/99 cards are also used to impose constraints on the number of aircrews that are available to replace losses incurred from airbase attacks. The aircrews for aircraft type AC are referred to as personnel type NOPEOP + AC.

The special CT20/66 card is used to enter any "aircraft transfer directives" that are to be activated during the simulation. These directives permit the user to move aircraft from a host base (e.g., MOB) to each of several DOBs whenever desired, and to direct that they be returned to the host at some later time. The entries on CT20/66 indicate the time at which a transfer is to begin, the bases involved in the transfer, the type and number of aircraft to be transferred, and (an option) the mission assignment for aircraft to be transferred from a host base. Up to eight such transfers may be active at any time at a particular airbase, and up to 50 (currently) such transfers may be entered for a given simulation.

If a directive is activated to transfer aircraft of a particular type from Base #B to Base #A, and another directive is later activated to transfer that same aircraft type from Base #A to Base #B, the earlier directive is canceled. Also, if the user wished, for example, to transfer aircraft from Base #C each morning, and return them each evening, the FREQuency could be specified for each of the two directives as "1" day, and the pair of transfer directives would be activated at the proper times each day. If a directive is issued to transfer some number of aircraft between two bases, and only the number differs from a prior directive, the old directive is replaced by the new directive. If more than eight transfer directives are specified for a particular base, the earliest directive is canceled to provide space for the latest.

Sample Data

Bases #1 and #2 each have 24 Type #1 aircraft and 30 aircrews organized into two squadrons. Twelve Type #1 aircraft are available in the theater as fillers and can reach their assigned base in two hours. Another 12 Type #1 replacement aircraft are available outside the theater; CT33 specifies that these latter aircraft can reach their assigned base in 2.5 days. In addition to the aircrews that man these replacement aircraft, there are also ten aircrews for Type #1 aircraft (i.e., personnel type 201; NOPEOP + 1) available in CONUS to replace aircrews lost as a result of air attacks.

The CT20/66 cards direct that four Type #1 aircraft configured for mission #1 be transferred from Host Base #1 to the DOB at Base #3 at 0300 on day 1 and from Host Base #2 to the DOB at Base #4 at 0500 on day 1; four aircraft are to be returned from Base #3 to Base #1 at 1800 on day 3, and another four aircraft are to be returned to Base #2 from Base #4 at 1500 on day 4.

Card Type #21

BASE PERSONNEL - PEOPLE ARRAY -

Card Type	Base	Type	Total Actual	Total Authorized	Day Shift Actual	Day Shift Authorized	Nom Shop	Min Size	Type	Total Actual	Total Authorized	Day Shift Actual	Day Shift Authorized	Nom Shop	Min Size	Type	Total Actual	Total Authorized	Day Shift Actual	Day Shift Authorized	Nom Shop	Min Size
21	1	1	48	48	30	30	1	2	2	16	16	8	8	2	2	3	10	10	6	6	3	3
21		30	6	6	4	4	5	2														
21	88	1		2																		

Airbase personnel resource descriptors include the number on the day shift and the total number on base at zero time; the difference is assumed to be on the night shift. In addition to "actual" values, the user must also enter the "authorized" level for each of these two factors. The authorized level may be the same as the actual level or different. The authorized levels are used in TSAR to determine resource reallocation among on-base organizations when losses are sustained, or when new personnel arrive on base; they are also used in the theater resource management algorithms. Whenever there is a change in the total number of people of a given type on a base, the authorized levels are used to apportion the new force between the two 12-hour shifts and among the squadron and wing-level organizations, subject to the minimum shift size constraints. When personnel are considered for reallocation among airbases, the authorized levels are assumed to be the appropriate number of each personnel type when the airbase has its full complement of aircraft. The personnel descriptors also indicate the shop to which each personnel type is assigned and the minimum number of personnel that should be permitted to be assigned to a shift. The assigned shop should correspond to the shop that handles the majority of tasks assigned to this personnel type.

When the base is organized in a 66-5 (POMO) structure, some personnel types will be divided into several groups; a group is assigned to each squadron, and one is assigned at wing level. When this occurs, the personnel in each separate group must be given a distinct personnel number. The lowest such personnel number must be assigned to personnel in the first squadron, the next lowest such number must be assigned to personnel in the second squadron, etc.; the highest such number must be for personnel assigned at wing level. Furthermore, the shop assigned for each of such equivalent personnel types must be the same. Equivalent personnel types are identified as such with the CT45/1 cards. When personnel are designated for on-equipment tasks on CT5, the lowest type number for the specialty (i.e., those assigned to squadron #1) *must be specified*; parts and equipment repair tasks should specify wing-level personnel.

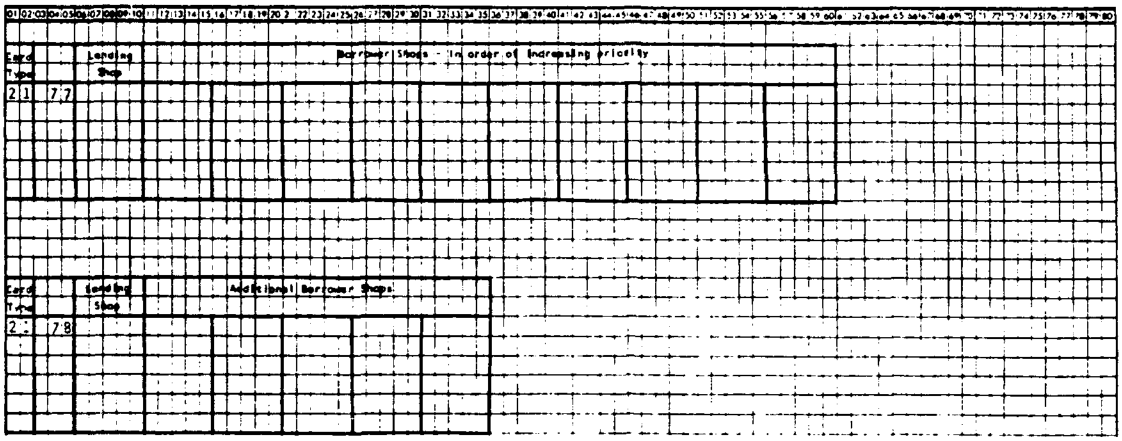
Civil engineering personnel are treated in a distinct manner; their numerical designations must be greater than (NOPEOP – CEPEO), so that they may be identified.

Sample Data

The first card image indicates that Base #1 has 48 Type #1 personnel, 16 Type #2 personnel and 10 Type #3 personnel; of these, 30, 8, and 6, respectively, are on the day shift. The minimum shift size is two for Types #1 and #2, and three for Type #3.

The second card image assigns six Type #30 personnel to each of the bases, because no base number is mentioned. The third card image specifies that Base #2 should be staffed with the same numbers of personnel as Base #1. Because no limits on replacement personnel are specified with a CT21/99 card, all personnel losses will be replaced if so specified with the CT33 cards.

Card Types #21/77 and #21/78



When personnel are released and a follow-on assignment is sought, the tasks waiting in the shop to which the personnel are assigned are checked first; if personnel are not needed there, tasks waiting in the shops listed in the BORROW array are checked next, one shop at a time, thus prioritizing how the personnel are assigned. Since the BORROW array is generated during initialization by checking the personnel specified in the procedures described with the CT5, CT8, and CT10 cards, and then the personnel assignments implied by the CT45/2 cross-training instructions, the order of borrowing shops is haphazard, being listed as they are found in the data, rather than on the basis of any priority.

The CT21/77 card modifies the order in which the borrowing shops are checked in order to control the priority in assigning personnel. The Lender and BORROWer arrays are listed in the output during initialization (if PRINT $\geq$ 4), thus providing the user a basis for designing the CT21/77 entries deemed appropriate.

The first field on the CT21/77 card identifies the shop that lends the personnel. The second through eleventh fields provide for the numbers of up to ten shops that are to be given priority in checking for waiting tasks. The program takes these entries, one at a time, and reorders the list in the BORROWers array, by placing the entry at the beginning of the list of borrowing shops. If several shops (up to ten) are to be reprioritized, the last entry in the list on the CT21/77 card will be given the highest priority since it is the last to be placed at the beginning of the borrower's list.

The CT21/78 card provides the additional capability to add shops to the lists of borrowing shops. This would be desirable in cases in which, for example, personnel type #1 from Shop #A have been cross-trained for tasks normally carried out in Shops #B and #C by personnel that are assigned to Shop #C. The program would use the cross-training data (CT45/2) to list Shop #C as a borrower from Shop #A, but Shop #B would not be listed. CT21/78 extends the borrowers list to include Shop #B, in this example. When #A is entered in the first field of a CT21/78 card, and #B (and whatever other shop numbers) are entered in the second (and subsequent—a total of five) fields, Shop #B (and the others) will be added at the end of the borrowers list. If a different prioritization is desired, a CT21/77 card can be used as described above. Thus, a CT21/78 entry must be entered before the CT21/77, if the newly added shop is not to be the last shop checked.

Card Type #22

BASE ACF AND EQUIPMENT - AGESTK ARRAY -

Card Type	Base No.	Type AGE	Total Act.	Total Tgt	Shop	Type AGE	Total Act.	Total Tgt	Shop	Type AGE	Total Act.	Total Tgt	Shop	Type AGE	Total Act.	Total Tgt	Shop
22	1	7	1	1	10												
22	188	1		2													
22		2	4	4	2	3	3	3	4								
22	1	2	3	3	2												

For each type of support equipment (AGE) included in the simulation, the CT22 entries include the total number of pieces of equipment on base at zero time, a target level for the total number, and the number of the shop to which the equipment is assigned. The total on base and the target number would be the same if the base were fully stocked (except that the target level may not exceed 99).

If the base follows a POMO (66-5) maintenance doctrine, and as a result some equipments are assigned to different organizations, they will be numbered differently, similarly to the personnel data described for CT21, and stocks for each of the organizations will need to be specified; the equivalent types are identified with the CT46 cards.

Equipment used by civil engineers must have designations greater than (NOAGE – CEAGE).

Sample Data

The first card image equips Base #1 with one piece of Type #7 AGE and assigns it to Shop #10. The second card equips Base #2 with the same AGE that has been designated for Base #1, up to this point. The third card image equips all bases with four Type #2 AGE and three Type #3 AGE. The fourth card image changes the initial stocks of AGE Type #2 to three at Base #1.

Card Types #22/66 and #22/77

AIS DESCRIPTIVE DATA							AISDTA Array		
Card Type		Type of Station	Number of First Tray	Prop AWP per Repair x 10000	Part Replacement Time		AIS Maintenance Time (percent)		AGE Equivalent
					Days	D	1 Station	>1 Station	
22	66	3	9	131	6	2	33	26	18

Card Type		Number of Tray	CONDITIONAL PROBABILITY TRAY IS AFFECTED BY AWP x 10000 - TRAYS Array - I	I+1	I+2	I+3	I+4	I+5	I+6	I+7	I+8	I+9
22	77	1	1200	700	560	140	973	1680	1320	912	415	1265

The specialized support equipment used for testing and repairing avionics on late model aircraft—the AIS or Avionics Intermediate Shops—may be simulated in TSAR. The manner in which the special characteristics of AIS are modeled in TSAR is discussed in Sec. VI, Vol. I. Whenever an LRU repair is completed using an AIS station, additional station time is allocated for maintenance of the station. This is handled by increasing the LRU repair time by a user-specified percentage. When that time is over, a check is made to see if any piece part needed for station maintenance was not in stock. If so, the station's residual capability to repair LRUs is estimated on the basis of statistics that indicate how frequently each particular LRU repair capability is lost, on average, when an AIS part is back-ordered. In the model, each station is divided into a number of sections, or "trays," one tray for each type of LRU, and when a part is back-ordered the residual mission capability for all trays in the station is determined on the basis of the statistical experience.

To organize the necessary input data, the user must number each type of station and each "tray" associated with each station. The station type numbers should be in sequence beginning with Type #1 and the trays should be numbered consecutively from the first tray in station #1 to the last tray in the last type of station. The user then identifies the correspondence between the AGE type and the station type on CT22/66, and between the part number and the tray number with entries in the AISDTA array (see cols. 11–15 on CT22/66) and in the TRAY array (see CT23/78). The CT22/66 and CT22/77 provide the rest of the required data.

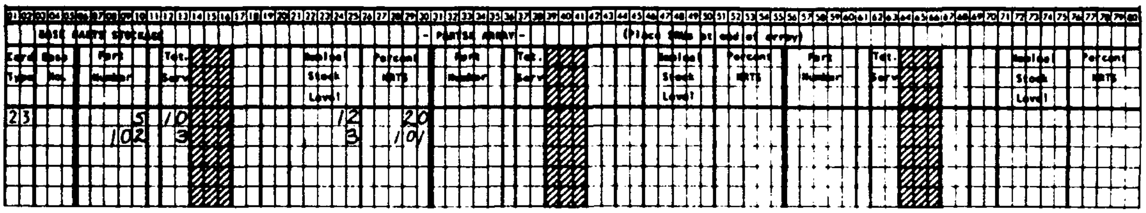
The entries for each type of station on CT22/66 include the station-type number, the location in the TRAYS array of the first tray associated with the station (columns 11–15), the probability that a part will be unavailable for AIS maintenance following each use of that AIS station (columns 16–20), the order and ship time to replace a needed part (columns 21–25), the increase (a percent) in LRU repair time to be used to represent AIS maintenance (columns 26–35), and the number of the equivalent AGE (columns 36–40). The probabilities that each individual tray can no longer repair its associated LRU when a part is missing are entered with CT22/77.

Sample Data

The CT22/66 card provides characteristics for the #3 type of AIS station. The first "tray" associated with this station is located in the ninth position in TRAYS array. After 1.31 percent of the times this type of station is used, a piece part required for maintenance of the AIS is unavailable and must be ordered; six days, on the average, are required to obtain the needed component. The actual repair time for each LRU processed on station #3 must be increased by 33 percent, to account for necessary AIS maintenance (if two or more stations of the same type are available for cross-checks, hot mock-ups, etc., only 26 percent additional time is required). The equipment or AGE identification number for the #3 AIS station is #18.

When a piece part is required to service an AIS station and it is not available, the subsequent mission capability of the station is affected as specified by the CT22/77 card. In this instance there is a 12.0 percent chance that the LRUs associated with Tray #1 will not be reparable if a piece part is unavailable for AIS maintenance; the likelihood for the other trays varies from 1.40 percent for Tray #4 to 16.80 percent for Tray #6.

Card Type #23



Ten distinct formats are used in connection with CT23 to permit the user either to specify spare part stock levels explicitly or to direct TSAR to generate exemplar stock levels consistent with user-specified parts procurement policies.

Entry of Specific Stock Levels

When the user chooses to enter the stock levels explicitly, the first of these CT23 formats is used; entries include the number of serviceables (i.e., available spares) and the "normal" or authorized stock levels. The percent of reparables that cannot be repaired on base—the NRTS rate—is also entered. When an on-equipment task is initiated, tests are made to see if a part is broken; if it is, it begins an administrative delay (CT47), after which it is sent to the appropriate shop. When the NRTS rate is 100 or less, a part that is to be NRTSed must be bench-checked, using the normal repair procedure, or, for parts that have several alternative procedures, using the first of these. When the NRTS rate is 101, the part is prepared for shipment immediately without being subjected to an administrative delay or bench-check at the shop.

The "nominal stock level" at an operating base is taken to be the level that is authorized for the aircraft initially assigned to that base, and it is used with certain of the decision algorithms for reaching judgments during the simulation as to which bases have the greatest need for parts. When a base has been designated as a CIRF, or as the location of the theater manager, the "nominal stock level" at that base defines the minimum stock level to be maintained at that location; serviceables above this level are "pushed" to the "most needy" base, if that resource management mode has been selected. The number of serviceable parts of any given type that may be specified on CT23 may not exceed 320, and the nominal stock level may not exceed 250.

Several other CT23 formats are illustrated in Figs. 9 and 10. The CT23/74 card supplies data as to which bases may be checked for a part when the simpler of the two

POLICY DATA — POLICY ARRAY —

Card Type	Base	Element No. of Ith Item	I NRTS	I BUY	I+1 NRTS	I+1 BUY	I+2 NRTS	I+2 BUY	I+3 NRTS	I+3 BUY	I+4 NRTS	I+4 BUY	I+5 NRTS	I+5 BUY	I+6 NRTS	I+6 BUY	I+7 NRTS	I+7 BUY	I+8 NRTS	I+8 BUY	I+9 NRTS	I+9 BUY
232		without CIRP																				
232	1	11	43		28		63	1			4											
233		with CIRP																				
233	1	11	66		80		100		80		100											

PARTS COST DATA ($100s)

Card Type		Number Ith Part	I	I+1	I+2	I+3	I+4	I+5	I+6	I+7	I+8	I+9
23	66	11	17	162	93							

BASE DATA — BEARTS ARRAY —

Card Type		Base No.	Base Kind	Type Aircraft	Number Aircraft	Sortie Rate (x 00) Peace	Sortie Rate (x 00) War	Base Repair Time Hours Peace	Base Repair Time Hours War	Order/Ship Time Days Peace	Order/Ship Time Days War	Travel Time Hours	No on-base SRU Stocks *
23	70	1	1	1	24	80	240	72	48	10	20		
23	70	2	1	1	24	80	240	72	48	10	20		

* SRUs not stocked at OLs for CIRF-eligible LRUs if = 1; all LRUs if = 2.

Fig. 9—Automatic spare parts initialization data

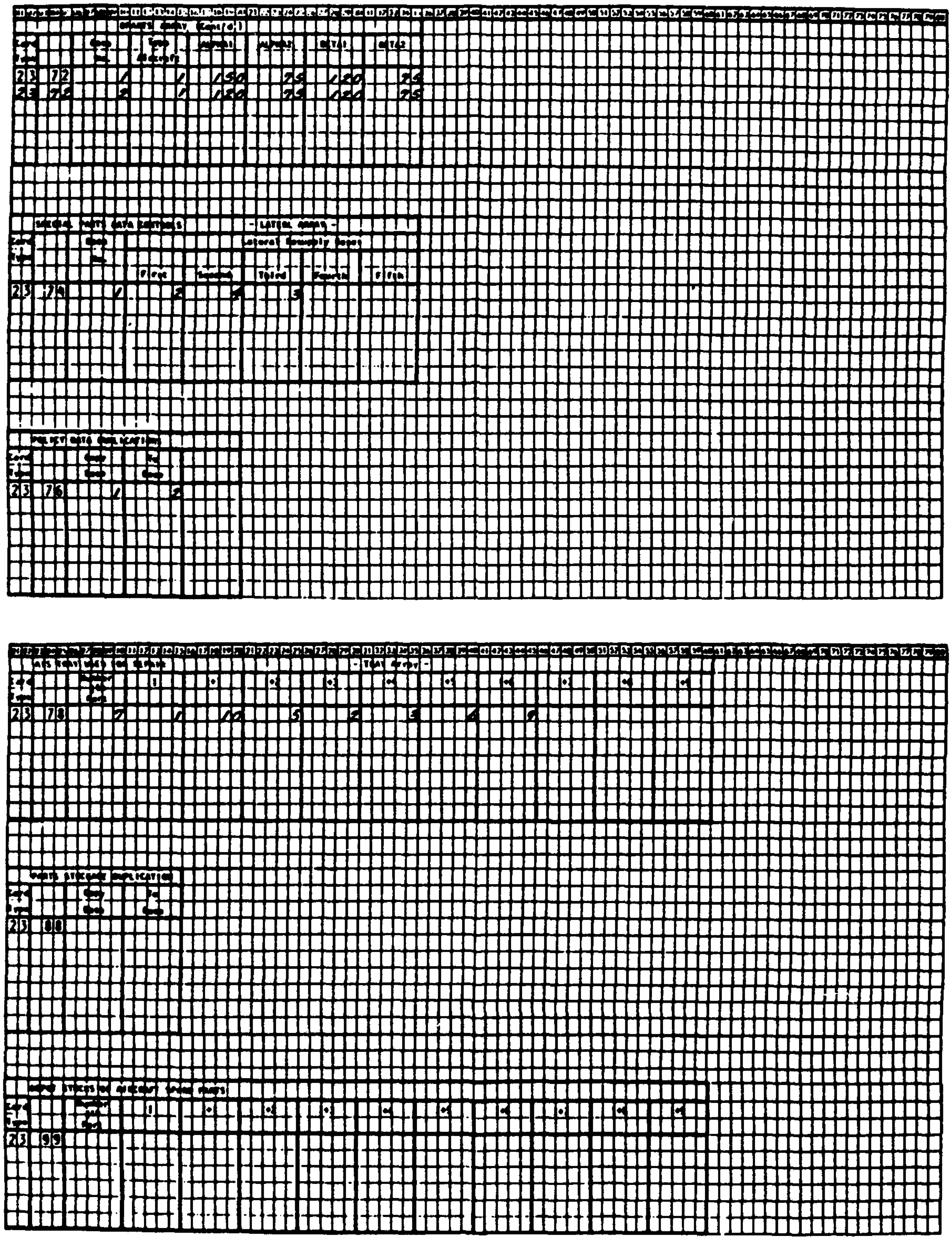


Fig. 10—Auxiliary spare parts control options

lateral supply doctrines is used. The calling base is entered in columns 6–10, and the bases that may be called are entered in the next 14 5-column fields; these 14 bases are called in order. A CT23/88 and CT23/99 can be used to have the parts at one base duplicated at another, and to constrain the quantities of spare parts available at depots for replacing losses. CT23/78 is used to identify the corresponding tray number (see CT22/77 and Sec. VI, Vol. I) for those LRUs and SRUs that are repaired with AIS equipment.

Parts Stockage Algorithms

TSAR provides special subroutines that permit the user to generate the parts stock levels for any base; these are activated when OUTFIT is initialized on CT3/3. The parts provisioned are for those unscheduled maintenance tasks included in the shop collections whose occurrence is controlled by CT7 entries, and for those tasks specified with the CT29 shop-task collections. The numbers generated are either appropriate for a wartime readiness spares kit (WRSK) or are the total of POS and BLSS, depending upon the user's specifications. They do not, however, make any provision for the additional parts that may be needed for repairing aircraft damage sustained in air battle or in airbase attacks.

CT23/70 and CT23/72 are used with the parts generation option to describe those factors that define stockage policy. They include the base number and kind, as well as the type and number of aircraft; and the nominal sortie rates, base repair cycle times, and order-and-ship times in peace and war; and safety factors. Base kind determines whether the aircraft are in place and the base is to be stocked with POS and BLSS, or the unit has been deployed into the theater with a WRSK kit; kind is 1 for the former and 2 for the latter. If a CIRF is simulated, it must be assigned its own base as well as its own NRTS rates and other policy factors, except that no aircraft are to be assigned at that location. The order-and-ship times for operating bases should be the value that would be appropriate in the absence of the CIRF.

NRTS data for the parts stockage algorithms are entered using CT23/20x and CT23/30x for each part type. The CT23/20x cards define that fraction of parts that would be NRTSed at base x if there is no CIRF in the theater, and the CT23/30x cards define the same data for the case in which there is a CIRF. If a part, LRU, or SRU is NRTSed 100 percent of the time but first undergoes a normal administrative delay and then a shop check, the NRTS value is entered as 100; if the part is NRTSed immediately

without a bench check, the NRTS rate should be entered as 101. A null NRTS rate on a CT23/20x card is interpreted as a zero NRTS rate. If no CT23/20x is entered for certain parts (and OUTFIT > 0), the NRTS rate will be assumed to be 101.

The "buy" column on the CT23/30x card is currently not used; on CT23/20x a 1 entered in the "buy" column prohibits procurement of that part type for a WRSK. The various stockage calculations are explained at greater length in Sec. VI, Vol. I. If the POLICY array data entered with CT23/20x and CT23/30x are the same at two bases, a CT23/76 card can be used to duplicate the data for one base at another. (Since a CT23/76 duplicates only that data already entered, this card can be used to copy some, but not all, POLICY entries from one base to another, by appropriate placement of the card among the entries for the first base.)

When a CIRF is not simulated, the CT23/30x cards may be used to provide the user an option to modify the NRTS rates at a specific time during the simulation. This might be desirable, for example, when intermediate repair facilities become available, as at a COB. To use this option, see the instructions for shipping part Type #10000 with CT31.

CT23/66 provides the unit cost data that are used to calculate WRSK stock levels with an algorithm that approximates the DO-29 WRSK calculation (when PMODE = 1 on CT3/3); these data are also used to compute the total costs for all the parts procured and "authorized" for each base, and to determine which parts at a base are in short supply when TOOFEW (CT3/3) is –1.

If the control variable FULL that is defined on CT3/3 is zero rather than one, some number of each type of part whose NRTS rate is > 0 will be entered into the supply pipeline for delivery at random times after the simulation begins. If the user wishes to specify that the stocks that have been procured are short of the computed allowances, two procedures are provided. The first procedure reduces the estimated stock level for each type of part by SHORT percent. The second procedure is activated if TOOFEW is not zero; it reduces the stock level for a portion of the part types to a value chosen at random between K1LOW and (K1LOW + K2LOW) percent. If TOOFEW is greater than zero, [TOOFEW/10] percent of the part types is chosen at random to be shorted. If TOOFEW is –1, the probability that any part type is shorted is equal to that part's unit cost divided by the unit cost of the most expensive type of part (CT23/66). These procedures may be used separately or together. If RANDM is one, the availability of

each part is determined by a random draw (see CT3/3); otherwise the shortage is the expected value of the shortage.

Parts for battle damage repair can be specified separately using the basic CT23 cards, or can be provisioned automatically by initializing columns 41–45 on CT15/2. Parts replaced for battle damage repair are condemned. Special parts stocks to repair aircraft damage resulting from airbase attacks must be entered with basic CT23, unless the CT15/2 ABDR parts entry can be adjusted to provide the needed parts.

Shortages (or overstockage) relative to the numbers computed with these various algorithms may also be represented by separately specifying negative (positive) numbers of parts with the basic CT23 cards. The user is restricted however, when OUTFIT > 0, to entering at most EXTPRT specific stock changes for each base, in addition to those generated by the stockage algorithms; the part types so entered may be the same as or different from those dealt with automatically.

Sample Data

The first card stocks all bases with ten serviceable Type #5 parts, 20 percent of which cannot be repaired on base. The target level is 12 parts of that kind. The second card image provides three spare #102 SRUs for Part #5; these SRUs are NRTSed immediately, without being checked, when they are faulty (i.e., NRTS = 101).

CT23/20x and CT23/30x present the NRTS rates that are used when TSAR generates spare parts stocks. These data indicate that in the absence of a CIRF, 43 percent of Type #11 reparables would be NRTSed at Base #1, as well as 28 percent of Type #12, 63 percent of Type #13, and 4 percent of Type #15. Furthermore, Type #13 parts would not be procured for WRSKs. The data also indicate that all #13 and #15 parts would be NRTSed if there were a CIRF, and 60 percent of part Type #11 and 80 percent of part Types #12 and #14 would be NRTSed. Without a CIRF no #14 parts would be NRTSed, because the null entry is taken to signify a zero NRTS rate.

The sample cost data on the CT23/66 card indicate that #11, #12, and #13 type parts have unit costs of $1,700, $16,200, and $9,300, respectively.

The policy options that will be used in automatically generating parts levels are illustrated with the CT23/70 and CT23/72 cards. Bases #1 and #2 are both to be treated as in-place units (KIND = 1) that each operate 24 Type #1 aircraft. The nominal peacetime and wartime sortie rates are assumed to be 0.8 and 2.4 sorties per aircraft per day; base repair times are 72 and 48 hours in peace and war, respectively; and the order

and ship times are 10 and 20 days in peace and war. The peacetime data are used to define the peacetime operating stocks (POS) and the spares in the parts pipeline at time zero, and the wartime data are used to define the additional provisioning necessary for the simulation. No base-CIRF travel time is entered because there is no CIRF. The safety factors (CT23/72) that are to be considered in computing stockage levels are 1.5 for LRUs associated with mission-essential tasks at Base #1, and 1.2 for these LRUs at Base #2. For other LRUs, the safety factor is 0.75. For SRUs the factors in these same circumstances are 1.20 and 0.75.

When parts are required at Base #1, CT23/74 indicates that Base #2 is first asked if they can fill the requirement; if not, Base #4 and then Base #3 are asked. CT23/76 indicates that the various NRTS data entered with the CT23/201 and CT23/301 cards for Base #1 also should be applied to Base #2. The CT23/78 cards specify which tray in the AIS string is associated with a particular LRU or SRU; these sample data specify that Trays #1, #10, and #5 are used with LRUs #7, #8, and #9, respectively.

BASE MUNITIONS STOCKS — MUNSTK ARRAY

Card Type	Base No.	Munition Type	Stock Level	Munition Type	Stock Level	Munition Type	Stock Level	Munition Type	Stock Level	Munition Type	Stock Level	Munition Type	Stock Level	Munition Type	Stock Level
24		1	160	2	200										
24		501	4000	502	2500										

BASE TRAP STOCKS — TRAP ARRAY

Card Type	Base No.	TRAP Type	Stock Level	TRAP Type	Stock Level	TRAP Type	Stock Level	TRAP Type	Stock Level	TRAP Type	Stock Level	TRAP Type	Stock Level	TRAP Type	Stock Level
25		1	20	2	20	3	10	4	20	5	5000				

CIVIL ENGINEERING BUILDING MATERIALS — MATERL ARRAY

Card Type	Base No	Material Type	Stock Level	Material Type	Stock Level	Material Type	Stock Level	Material Type	Stock Level	Material Type	Stock Level	Material Type	Stock Level	Material Type	Stock Level
26		1	6000	2	8000	4	2000	6	1000						

BASE POL STOCKS (Thousands of Pounds) — POLSTK ARRAY

Card Type	Base No.	POL	Base No.	POL	Base No.	POL	Base No.	POL	Base No.	POL	Base No.	POL	Base No.	POL
27	1	27000	2	23000	3	7000	4	7000	5	3000	6	8000		

Fig. 11—Additional resource initialization data

Card Types #24, #25, #26, and #27

The cards in Fig. 11 specify the initial stocks of munitions, TRAP, building materials, and POL. The "J = 99" version of each card type permits the user to indicate the stock levels available for resupply for whichever resources have resupply limitations. Use of the normal munitions type number designates assembled munitions; for unassembled munitions, add 500 to the nominal type number. If munitions are to be assembled from subordinate components, the available quantities of each component are also entered with CT24; the type designation of such components must fall between the values NOWEAP and NOMUN. When quantities of unassembled weapons are specified for munitions whose components have been designated with the CT11/2 cards, they are broken down and stored as the appropriate numbers of components.

Sample Data

These two CT24 stock all operating bases with 160 Type #1 and 200 Type #2 munitions that are assembled, and 4000 and 2500 of the same types that are unassembled. Since the components of the Type #1 munition were designated with a CT11/2, 4000 each of Type #52, #53, and #56 components are put into stock.

The CT25 provides 20 items of TRAP #1, #2, and #4, 10 items of TRAP #3, and 5000 items of TRAP #5 at all bases. CT26 provides the same stocks of four building materials at each base, and the CT27 card provides 27000 units of fuel at the first operating base and 23000 units at the second; the two dispersed operating bases (#3 and #4) each have 7000 units of fuel, the rear maintenance base (#6) has 8000 units of fuel, and the base to be used for emergency recoveries, Base #5, has 3000 units.

Card Type #28

PARTS LIST — PRTLST ARRAY —

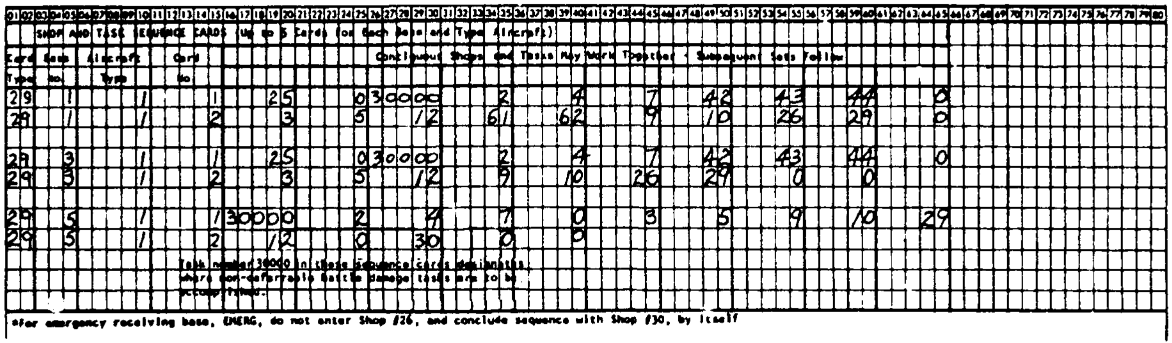
Card Type	Prt List No.	Part No.	# AC	Part No.	# AC	Part No.	# AC	Part No.	# AC	Part No.	# AC	Part No.	# AC	Part No.	# AC	Part No.	# AC	Part No.	# AC	Part No.	# AC
28	1	1		2		3		4		5		6		7		8		9		10	
28	11	11		12		13		202		203		205		0							

These cards define the one-dimensional parts-list (PRTLST) array. These data are used only when parts are to be salvaged from an aircraft too badly battle damaged to repair. The numbers of all parts and all LRUs on each aircraft type that are to be considered eligible for salvage should be entered, as well as the quantity of each of these items that might be recovered from the aircraft. If the quantity is left blank, it is assumed that only one part of that type may be salvaged. A zero part type denotes the end of the parts list for each aircraft type. The position in the array of the first entry for each aircraft type is specified on CT15/1 for that aircraft. The position within the PRTLST array of the first of the entries on each card is defined by the value in columns 6–10.

Sample Data

These CT28 cards list the 16 types of spare parts that can be salvaged from Type #1 aircraft, thereby defining the first 16 elements of the PRTLST array. If salvage parts were to be listed for another type of aircraft, the list should begin in the 18th element of the PRTLST array, leaving the 17th element null.

Card Type #29



These cards define the order in which on-equipment aircraft maintenance tasks are to be scheduled. Tasks may be entered individually or as collections of work center (shop) activities. Shops #1 through #24 may be used to designate task collections. Entering a shop number implies all tasks that were associated with that shop number in the SHPTSK array using a CT7 card. To be distinguishable, all numbers less than 31 are interpreted as shops and all other numbers as tasks. Shop #25 designates the mission dependent postflight inspection tasks that the user may have specified with CT15/5, and Shop #29 designates refueling. Shop #26 designates a sequence of activities: final mission assignment, required reconfiguration, and mission-dependent munitions loading. Shops #26, #27, #28, and #30 should not be specified except in the special case of the EMERG base, where "Shop 30" is specified to designate that the aircraft is ready to be returned to its parent base, when that base is again operational. The number 30000 is used to designate all battle damage tasks.

The order in which tasks are carried out is controlled by the position of the task and shop numbers on these cards. The numbers may be entered in any order; when two or more tasks or shops may be worked at the same time, the numbers are entered in successive fields. If two groups of tasks or shops may not work on an aircraft simultaneously, and one must follow the other, they will be separated by a null entry in a field. The last item is denoted by two following null entries. Task organization may be further modified and controlled by the LISTIN array of incompatibility data (see CT19).

Up to five cards may be used to enter the task and shop sequence for each base-aircraft-type combination. A distinct set of cards is required for each combination, unless the base number is not entered, in which case all bases will function in a common manner for the given aircraft type. (Note that the CT29 data generated for the

EMERGency recovery base with this null-base-number convenience will be incorrect; a separate set of CT29 cards can then be entered for the EMERG base that will override the first set.)

Sample Data

These six cards illustrate how the on-equipment aircraft maintenance task schedules in the TSAR demonstration problem are entered for the Type #1 aircraft at Base #1, at the DOB (Base #3), and at the EMERGency recovery base (Base #5). The "25" that appears first for Bases #1 and #3 signifies that the mission-dependent postflight inspection tasks should be performed first. After the inspection, the battle damage tasks (30000), maintenance tasks in Shops #2, #4, and #7, and the basic munitions and fuel tank loading Tasks #42, #43, and #44 should be completed. After all this, any work for Shops #3, #5, #12, #9, and #10, Tasks #61 and #62, uploading mission-dependent munitions (26), and refueling (29) will be done at Base #1; Tasks #61 and #62 are omitted at the DOB (Base #3). The tasks at the EMERG base exclude the postflight inspection and the munitions tasks and are concluded with "30" to designate that the aircraft is ready to be ferried to its regular operating base, when that is possible.

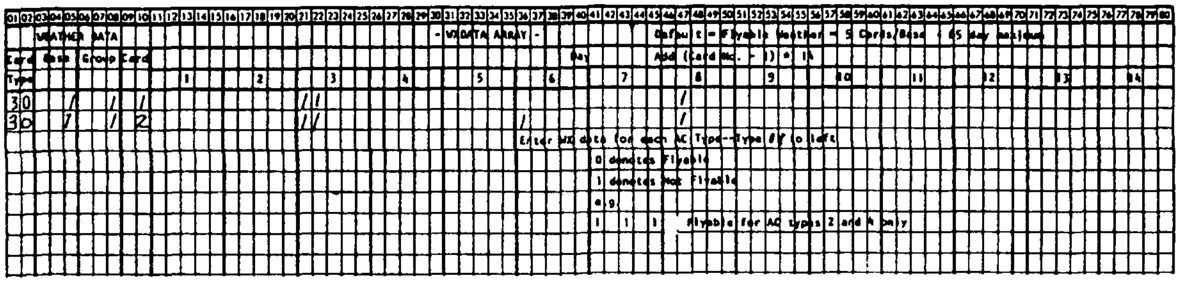
Card Type #29/88

Probability Air Crew Does Not Detect Unscheduled Maintenance Tasks entered with CT29

Card Type			Aircraft Type	Task Number	Prob. not Detected	Task Number	Prob. not Detected	Task Number	Prob. not Detected	Task Number	Prob. not Detected	Task Number	Prob. not Detected	Task Number	Prob. not Detected	Task Number	Prob. not Detected
					* 100		* 100		* 100		* 100		* 100		* 100		* 100
29		88															

If aircraft are operating from a dispersed operating base, it could be necessary to indicate that some of the tasks entered with the CT29 cards will not be detected before the aircraft lands at the DOB. The CT29/88 cards permit the user to indicate the probability that unscheduled aircraft maintenance tasks are not detected before landing. Only unscheduled tasks that have been listed on CT29 should be included. If such a task is not specified on CT29/88, the task will always be identified before the aircraft recovers.

Card Type #30



The weather status can be entered for each base and each aircraft type for a 65-day period with these cards. Two groups of five cards with 14 fields each may be submitted for each base; the first group is used for the first five aircraft types; the second group is used for the last four aircraft types. Each field is filled with ones or zeros (blanks) to indicate the weather on the N*th* day. The left-most column of each field in the first group pertains to aircraft type number one and the right-most column to aircraft type number five; the left-most column of each field in the second group applies to aircraft type number six and the next-to-the-right-most to the ninth. A one signifies nonflying weather for a particular day-base-aircraft combination, and a zero denotes no weather restriction for that combination. If no data are entered, flyable weather is presumed throughout the 65-day period for each aircraft. On-equipment maintenance tasks that are not mission-essential and that have been deferred may be worked off during the day if the aircraft cannot fly because of bad weather.

Sample Data

Flying is interrupted by weather on five days at Base #1. Neither the first nor the second type of aircraft may fly on the 3rd or 17th days; the first type of aircraft is also grounded on day 20 and the second type on days 8 and 22.

COMMUNICATIONS SYSTEMS INPUT DATA

Card Type #31

RESOURCE SHIPMENTS FROM CONUS — CONUS and CARGO ARRAYS —

Card Type	Arrival Time Day	Arrival Time Hour	Base No.	Commodity Class	Commodity Number	Commodity Type	Commodity Class	Commodity Number	Commodity Type	Commodity Class	Commodity Number	Commodity Type	Commodity Class	Commodity Number	Commodity Type
31	5	17	1	1	5	7									
31				3	4	3	4	250	504	5	50	11	7	12	
31	7	21	2	8	4	1									

These cards permit the user to define resource deliveries from the United States (i.e., outside the theater). (These deliveries arrive regardless of attack damage at the destination or other scenario developments, and do not count against depot resource stocks that may be specified with the special CT2x/99 cards.) The format permits the user to specify the destination and time of arrival of each shipment from CONUS and the nature of the cargo. The destination and time need be specified only on the first of the cards defining the contents of a shipment, because the cargos specified on all subsequent CT31 cards are delivered at the same time and place until a new destination is encountered.

The maximum number of items that may be defined with a single entry is 250 (except for munitions and TRAP for which up to 6250 items are permitted), but any number of entries is permissible with the same shipment. For POL, 100 units are delivered for each unit entered on this card type; if the unit of measure on base is thousands of pounds, an entry of 50 on this card would direct the delivery of 5 million pounds—$50 \times 100 \times 1000$. (For POL, "type" is normally zero; if Type = 100, shipment is additional storage capacity.)

For personnel only, this card type may also be used to withdraw a specified quantity of specialists of a given type. To do this, the personnel type is entered as a negative value; this signals that the quantity is a withdrawal. If munitions are shipped preassembled, they should be designated by simply using the appropriate type number; unassembled munitions are designated with the type number + 500.

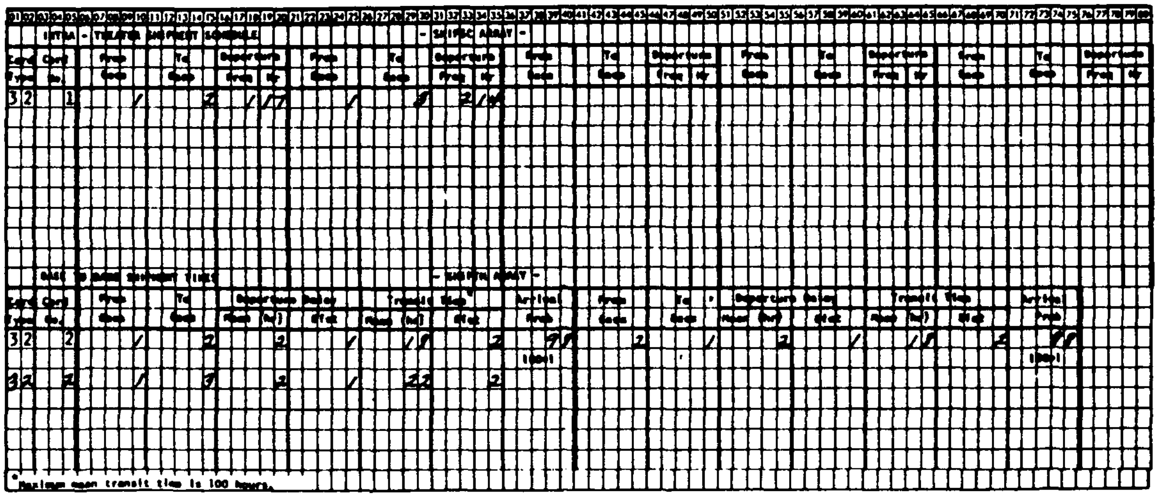
This card type is also used to change the NRTS policies of a base, but can be used only when no CIRF is simulated. Such a change might be desirable, for example, when intermediate repair facilities become available for a unit deployed to the theater (e.g., at a COB). The time to effect the change is signaled by delivery of a Type #10000 part

(Class #3) to the appropriate base. At that time, the NRTS data that had been entered with CT23/20x for base x are replaced with the data entered with CT23/30x.

Sample Data

The first two cards specify that Base #1 is to receive a shipment from CONUS at 1700 on day 5. Included are five Type #7 personnel, four Type #3 spare parts, 250 unassembled Type #4 munitions, 50 Type #11 TRAP, and 1200 units of POL. Note that the arrival time and destination appear on only the first card. The third card indicates that four Type #1 aircraft are to be delivered to Base #2 at 2100 on day 7, regardless of aircraft losses at the base; if these aircraft are unable to land when they arrive, because of runway or shelter limitations, they will recover at another base.

Card Types #32/1 and #32/2



The CT32/1 and CT32/2 cards define the daily intratheater transportation schedule. The nominal departure times for all links in the transportation network are specified with the CT32/1 cards, and the transit times and delays, etc., are specified with the CT32/2 cards.

For each base combination the user may specify the expected departure delays and their distributions, along with the transit times and their distributions. The chance that a shipment is lost (to enemy action or otherwise) is also entered with these cards.

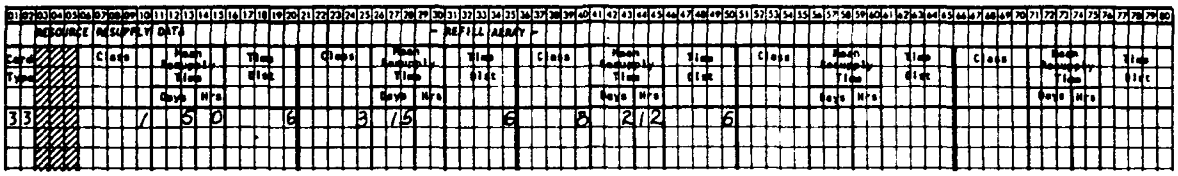
Sample Data

The CT31/1 card indicates a daily shipment at 1700 from Base #1 to Base #2 and a shipment every other day at 1400 from Base #1 to Base #3. When shipments are not daily, the day for the first shipment is picked at random.

The CT32/2 data indicate that all intratheater shipments from Base #1 to Base #2 leave an average of two hours late and take 18 hours on the average to reach their destination. The actual departure delay and transit time are determined by random selections from distributions #1 and #2, respectively. There is a 2 percent probability that each shipment is lost enroute.

For shipments from Base #1 to Base #3 the arrival probability was not entered. The default value is 100 percent, so no losses will be experienced along that route.

Card Type #33



These cards permit the user to simulate the requisitioning and resupply of resources that are lost in combat or during an airbase attack, and of parts that are not reparable in the theater. For those classes of resources that are specified with these cards, such losses are replenished from CONUS after a delay that is controlled by the mean resupply time and the time distribution. The numbers that designate the various resource classes are:

1 – Ground personnel	5 – TRAP
2 – Equipment	6 – Building materials
3 – Parts	8 – Aircraft
4 – Munitions	9 – Aircrews

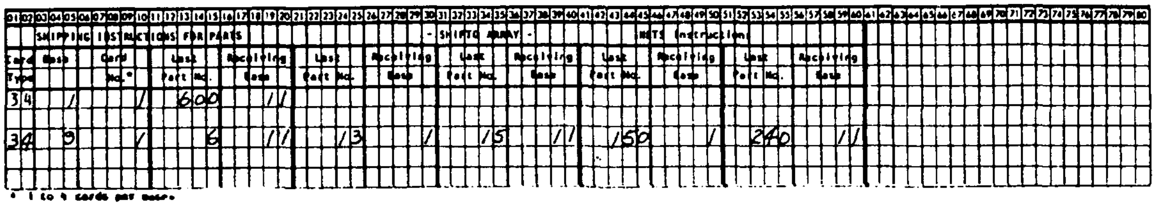
Note that the number 9 is not used to designate facilities; this is the only exception to that usage in TSAR. Also, POL is not included at this time.

Whenever losses are suffered by any type of resource of the classes that are entered, a resupply shipment of the same quantity and type is scheduled to arrive at the location that suffered the loss after an appropriate delay. If the stocks available for resupply are limited, the limits for each type of resource are specified with the "J = 99" version of each of the resource stockage cards (i.e., CT20/99 through CT27/99). Aircraft spare parts that are condemned or NRTSed out of the theater are treated identically.

Sample Data

With these illustrative entries, ground personnel that are lost to air attack would be replaced in an average of five days; parts that are lost or are not reparable in the theater would be requisitioned from CONUS with replacements arriving in an average of 15 days. Aircraft lost in combat or from airbase attack would be replaced in an average of 60 hours. In each case the actual resupply time is established with a sample from the #6 distribution (i.e., plus-or-minus 30 percent, relative to the mean). See App. I in Vol. III for definitions of the distributions that are currently available in TSAR.

Card Type #34



These cards provide the instructions for each base for the disposition of NRTS parts. The entries define which parts numbers are to be NRTSed to which locations. For each base, all parts numbered from #1 to the first part number on CT34 are NRTSed to the first base listed on CT34. Subsequent part numbers up to and including the second part number on CT34 are NRTSed to the second base listed on CT34, etc. If all NRTSed parts are to go to a common base (e.g., a CIRF), only one entry would be necessary—i.e., the highest relevant part number and the repair base number. If parts are to be NRTSed to various bases, the number of required entries can be limited if the part numbers going to a common base are organized into contiguous groups. However, since the organization of data in the *CT5 and CT8 cards will often prohibit* lumping all parts numbers into a few groups, CT35/5 has been provided so that the user can first specify blocks of part numbers as has just been described, and he may then override the base number specified with the CT34 cards for specific parts. Parts to be NRTSed to CONUS (i.e., out of the theater) are indicated by a base number that exceeds the maximum number of bases by one (i.e., MAXB + 1).

Sample Data

This card indicates that whenever Parts #1 through #600 are NRTSed at Base #1 they are all to be shipped to CONUS (i.e., MAXB + 1; MAXB = 10 in this example). At Base #3, Parts #1 through #6 are NRTSed to CONUS (Base #11), Parts #7 to #13 to Base #1, Parts #14 and #15 to CONUS, Parts #16 to #150 to Base #1, and all others (up to 240) are NRTSed to CONUS.

Card Types #35/1 and #35/2

CANNIBALIZATION TIME FOR PARTS - CANNTM ARRAY -

Card Type		Part No.	Time Min	Part No.	Time Min	Part No.	Time Min	Part No.	Time Min	Part No.	Time Min	Part No.	Time Min	Part No.
35	1	1	20	2	15	3	-30	4	20	5	24	6	-15	

PROBABILITY PART IS BROKEN WHEN CANNIBALIZED - BADCAN ARRAY -

Probability × 1000

Card Type		I^{th} Part	I^{th}	$I^{th}+1$	$I^{th}+2$	$I^{th}+3$	$I^{th}+4$	$I^{th}+5$	$I^{th}+6$	$I^{th}+7$	$I^{th}+8$	$I^{th}+9$
35	2	1	0	0	125	0	85	0	0	240		

The CT35/1 cards provide the user an opportunity to specify a time (CANNTM) different from the default value (see CANMUL on CT3/1) that is required to cannibalize a part. For parts that have had a cannibalization time entered on CT35/1, the nominal task time for handling the relevant task will be increased by this amount, when the required part must be acquired by cannibalization. If the entry on CT35/1 is −1, the part may not be cannibalized. If the entry is negative but not −1, the part may not be cannibalized except when the number of aircraft on base that require the part exceeds DOCANN (see CT3/1); in that case the nominal task time is increased by the absolute value of CANNTM to account for cannibalization.

If a value is entered for an SRU, the time required to diagnose and replace that SRU is increased by that value if an LRU is disassembled to obtain the required SRU. If no value is entered, the default value of the time that is added is one-half the nominal repair time for that SRU.

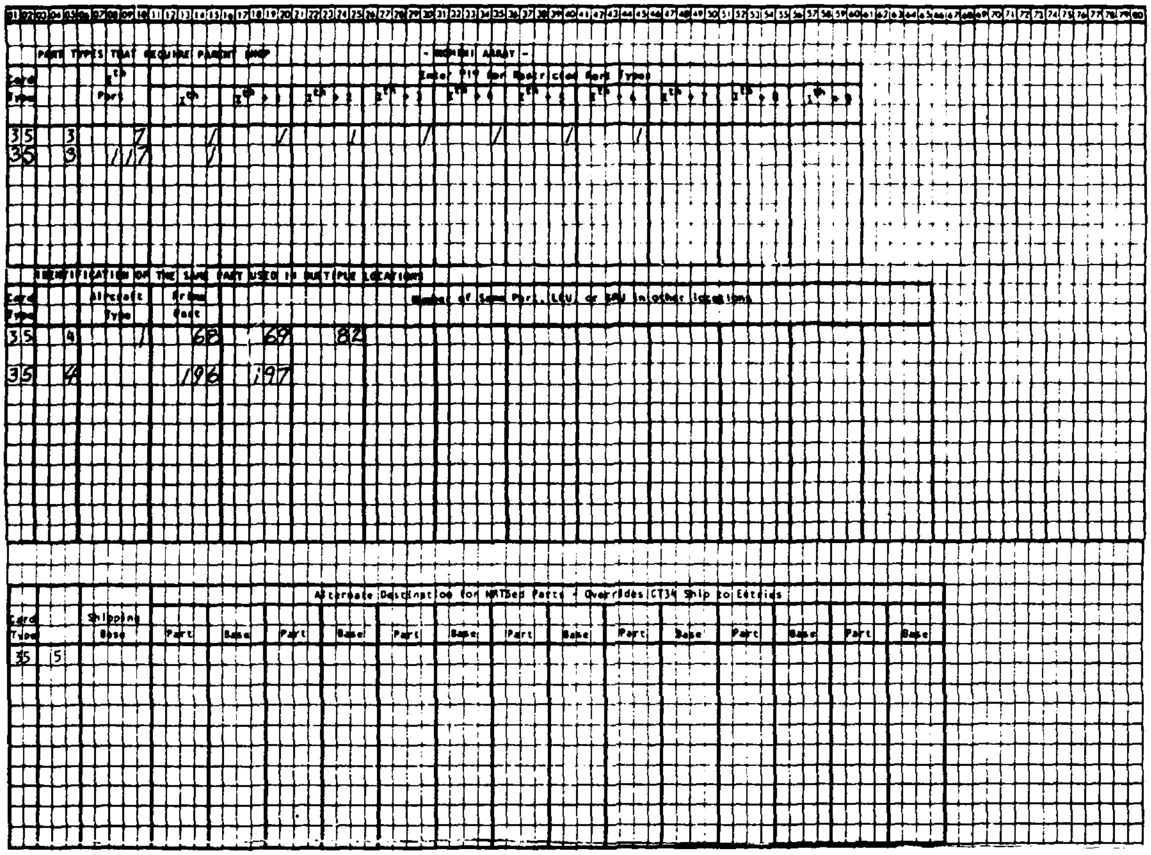
The CT35/2 card permits the user to specify the probability (× 1000) that a part that is being cannibalized from one aircraft to be used on another aircraft is itself broken during the cannibalization process. When this occurs, it is assumed that the aircraft that was to receive the part must obtain another part, and must repeat the task associated with that part, and that the donor aircraft is missing that part. When the probability that a part will be broken during cannibalization exceeds the special control variable NOCANN (CT4/2), no attempt will be made to cannibalize the part.

Sample Data

These CT35/1 data indicate that only 20 additional minutes are required to obtain a Type #1 part by cannibalization, rather than the 36-minute default value (i.e., the 25 TTU task time for Task #2; see CT3/3 and CT5). For Type #2 parts a time of 15 rather than 30 minutes is indicated. Part Type #3 cannot be cannibalized unless the number of aircraft that have this part missing exceeds DOCANN; if that condition is satisfied the task time is 30 minutes.

The CT35/2 indicates that parts #3, #5, and #8 have a 12.5, 8.5, and 24 percent chance, respectively, of being damaged during cannibalization.

Card Types #35/3, #35/4, and #35/5



The CT35/3 cards identify those parts that may be repaired only in the parent facility of a distributed shop. For parts so identified, the elements of a distributed shop other than the parent facility will not be permitted to handle the repair. This feature was designed to simulate the unique capability of the parent AIS facility to repair certain types of parts. When the repair capability for such parts is centralized at some bases but distributed at others, the relevant part numbers should still be entered with CT35/3; the constraint can then be overridden at those bases with distributed capabilities by entering 1 in column 65 on CT17/3.

When a part is used in more than one location on an aircraft (e.g., a left and a right tire or a left and right engine), CT35/4 permits the user to identify for TSAR the several part numbers that refer to the same physical object (i.e., LRU or SRU). In defining part requirements for tasks (and SRU requirements for LRU repairs), a different part number is assigned to each location; CT35/4 identifies the equivalence of the several part

numbers and defines one of the part numbers as the "prime" part. The TSAR program automatically treats the several parts as equivalent to the prime for procurement, repair, and distribution activities. TSAR will cannibalize a part from each of the locations in which it is used, and in seeking a part for cannibalization, the cannibalization times (CT35/1) and break probabilities (CT35/2), if any, are preserved for the several locations. Furthermore, like parts are cannibalized in the order of the times required for cannibalization.

Multiple locations for a part must be identified for each relevant aircraft type. The part number specified (in columns 11–15) as the "prime" part number of each part equivalence group must be the same for all aircraft types that use that part. This is necessary for correct operation of the TSAR logic concerned with managing parts used on more than one type of aircraft.

In addition to permitting a part or LRU to be used in more than one location on an aircraft, the TSAR code also permits an SRU to be used in more than one LRU, and in more than one location in the same LRU. Data to define these equivalences are the same as for LRUs, except that an aircraft type is not identified in columns 6–10 as with LRUs; each location in which the SRU is used *must* be identified with a *different* SRU number, and the fact that these several SRUs are equivalent *must* be identified for TSAR with these CT35/4 cards. Also, as with LRUs, one of the SRU locations *must* be defined as the "prime" location and that location *must* be located in a "prime" LRU. With these rules the several locations can be treated as unique for cross-cannibalization and fault location, but as a common type for procurement, repair, and distribution. Entries should be provided for each of the equivalent part types on the CT28, CT35/1, and CT35/2 cards, but should only be entered for the "prime" part on the CT8, CT23, and CT35/3 cards.

The CT35/5 card is provided so that the user may override the bases designated to receive NRTSed parts with the CT34 cards. This will sometimes be necessary because of difficulties in specifying contiguous blocks of part numbers on the CT34 cards. Alternatively, with small data bases, one might chose to use CT35/5 for all parts rather than a CT34.

Sample Data

The CT35/3 lists parts #7 through #13 and #117 as parts that must be repaired at the "main" shop, rather than in any distributed locations.

The first CT35/4 says that parts #68, #69, and #82 are identical and are used on Type #1 aircraft in three different locations; part #68 is defined as the "prime" part. The second CT35/4 indicates that a particular SRU appears in two locations and is known as parts #196 (prime) and #197.

Card Type #36

REPORT SCHEDULES, DELAYS, LOSSES - UNIT ARRAY AND REPORT ARRAY -

Card	Base	Transit Time			Loss Rate %		Daily Reporting Times																			
Type		Hours	Minutes	Dist	Item	Report	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min	Hour	Min
36	1	4	30	1		3	2	30	14	30																

Management of theater resources is based on base status reports that may be imperfect. These cards define when each base submits its status reports, and specify whether they are late, imperfect, canceled, or lost. Each base reports its current resource status each day at the times specified on CT36. The arrival time at "Theater Headquarters" is controlled by the submittal time and the uncertain transit time. The likelihood that any element of the transmitted data is received is governed by the "Item Loss Rate," and the likelihood that the entire report is lost in transit is governed by the "Report Loss Rate." The transit times must be such that reports are received before the next one is transmitted; if this rule is violated, the transit time will be shortened appropriately, and the change will be noted in the output listing.

Sample Data

These data specify that Base #1 reports to the control authority at 0230 and 1430 and that the reports arrive an average of 4 hours and 30 minutes later (the variance is controlled by distribution #1). There is a 3 percent chance that the report is lost in transit.

AIRBASE FACILITIES DATA AND ATTACK DATA

Card Type #37

BASE FACILITY DESCRIPTORS — FACLTY ARRAY

Card Type	Base	Building	Task Type	CW Type	Size	Alternate Bldg	Alternate Cap	Subsequent	S	Monitoring Point	CP Cap	Entry Time (min) (1(i))	Building	Task Type	CW Type	Size	Alternate Bldg	Alternate Cap	Subsequent	S	Monitoring Point	CP Cap	Entry Time (min) (1(i))
37		3	11	5	175	0	0		0	0	0	0	5	11	5	125	0	0		0	0	0	0
37		10	12	4	.400	101	5		0	0	0	0	101	12	4	50	102	10		0	0	0	0
37		102	12	4	50	0	10		0	0	0	0											
37		121	14	6	100	122	5		0	0	3	120	122	14	5	100	0	5		0	0	3	120

CT37, CT38, and CT39 jointly describe the characteristics of all on-base facilities, the procedures that are to be used for restoring them to an operating condition when they are damaged, and the priority for their restoration.

The entries in the CT37 cards for specific "buildings" are stored in the corresponding column of the FACLTY array. These "buildings" are the numbers of on-base facilities, as well as the storage location in the FACLTY array for subsequent repair procedure numbers. As explained in detail in Sec. VIII.2, Vol. I, the use of "building" *numbers between 1 and 50 are predefined.* For the buildings that deal with aircraft maintenance and parts repair, their "building" number must be identical to the "shop" number. Other numbers are reserved for squadron maintenance personnel, munitions assembly personnel, aircrews, etc. "Buildings" #36 through #38 are reserved for defining aircraft shelter repair procedures for three kinds of shelters.

The second (and ninth) field on CT37 has two entries and is used to define the "Task Type"—the number of the basic procedure to be used for repairing the "building"—and the "CW Type" of the "building." The resources required for each "Task Type" are defined with the CT38 cards. The "CW Type," by reference to the data entered with CT44/1, defines the characteristics of the building that are relevant for CW calculations.

Four Special CT37 cards are used in connection with repairs to runways and taxiways. The repair procedures used for runways and taxiways differ from those used for all other "buildings," and will be described shortly.

The "size" of the building, entered in the third (and tenth) field on CT37, is meaningful only in the context of the repair requirements specified with CT38 and *should*

not be entered for buildings that are not to be repaired[5] if damaged. The time and materials needed to carry out any repair are defined in terms of the required reconstruction, which equals the percent damage times the "size" of the building.

The fourth (and eleventh) field on CT37 provide the means with which the user can describe a distributed capability; the "Bldg" (a pointer) refers to the next building in the distributed set, and "Cap" is the capacity of the building being described. The entries for capacity should indicate the proportions of the activity that is carried on at each of the distributed locations; thus, if the capacity for three distributed locations was 5:10:25, 12.5 percent of the activity would be carried out in the first location (i.e., 5/40), 25 percent in the second, and 62.5 percent in the third. When the entries in this field are less than 50, they are interpreted as relative capacity; i.e., 1:2:5 would imply the same relative capacity as 5:10:25. However, when the entries exceed 50, they are interpreted as "absolute capacity + 50" when locations are sought for backshop repairs or munitions assembly tasks. Thus 51, 52, and 55 would imply that only 1, 2, and 5 tasks could be handled in each of the three locations, respectively.

TSAR permits the user to define a sequence of tasks as being necessary to repair any "building." The entry in the fifth (and twelfth) field refers to the column in the FACLTY array where the number of the subsequent procedure to be used in repairing the building is to be found; a 1 entered in the "Simul" column of the fifth (or eleventh) field indicates that the subsequent repair procedure may be carried out concurrently with the procedure defined on this card. It should be noted that columns of the FACLTY array assigned to subsequent procedures may *not* be used for an actual facility. Note also that only the "Task Type" field, and perhaps the "subsequent" field, are relevant when the FACLTY entry is a subsequent procedure. Another entry on CT37 permits the user to define the number of the monitoring point that is closest to the building; this entry is only to be used when conventional damage to the building is not relevant and the user wishes to avoid entering the building among the TSARINA targets. The last entry is used only for facilities designated as collective-protection shelters (see CT43/6); it indicates how many persons may be processed into the facility in one batch, and how long that processing takes (in tenths of minutes).

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[5]For those functions that are collocated in the same space, but are identified by different facility numbers, the building will be repaired only once if the TSARINA TGT cards for each function are entered in order, and if "SIZE" is specified on CT37 for only the first facility in the TGT card sequence.

Sample Data

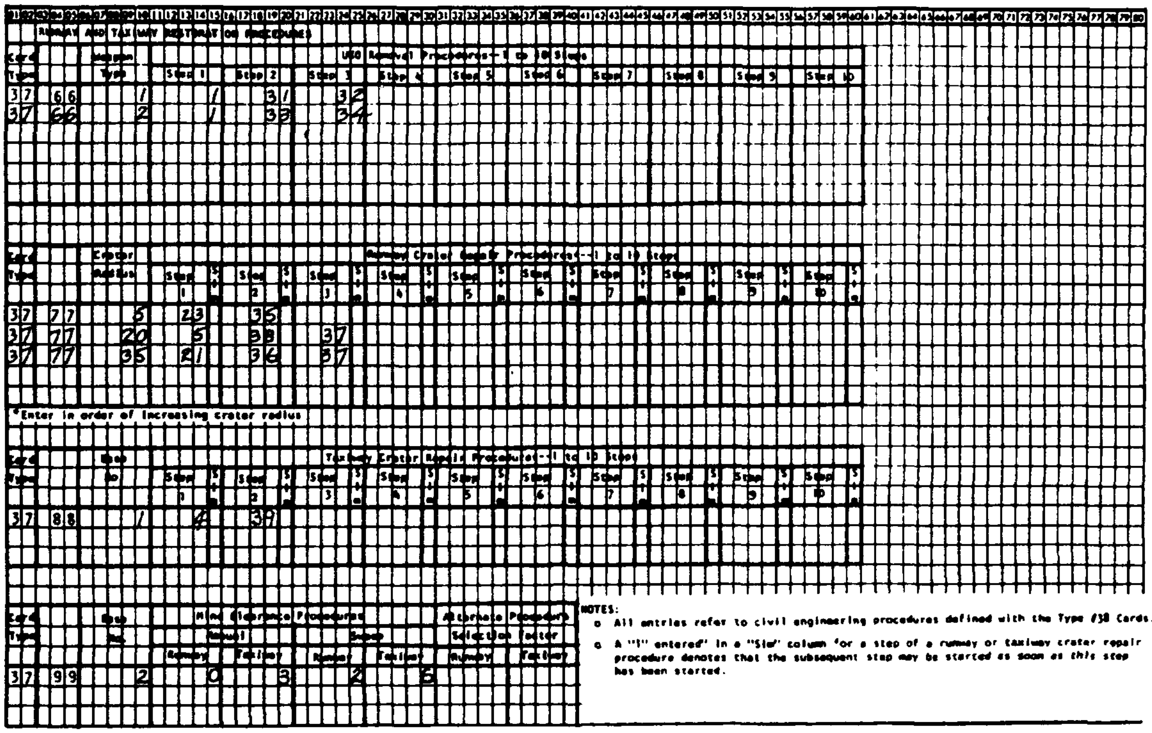
The first card indicates that facility #3 is to be repaired using procedure #11 and has the chemical protection characteristics of CWTYPE #5. When repair times and material requirements are computed they are to be based on a "size" of 175. Facility #5 is similar to facility #3, except for "size," which is 125.

The next two cards illustrate how a distributed facility is specified; the capabilities of facility #10 (Shop #10) are distributed to facilities #101 and #102, with the relative capacities for work at the three locations in the proportions 5:10:10. For repair, all would require procedure #12 and all are CW Type #4. The "parent" facility (Shop #10), although much larger than #101 and #102, is allocated only one-half as much of the capacity; the user might specify such relative capacities when he considered the "parent" facility more likely to sustain hits in an attack and wished to limit the number of tasks at risk.

The last CT37 lists two facilities being used for collective protection; for both, three persons can be processed into the shelter every 12 minutes.

Runway and Taxiway Repairs

Card Types #37/66, #37/77, #37/88, and #37/99



Four special CT37 cards provide the user with the means for introducing a detailed representation of the various runway and taxiway restoration procedures in use at each of the various airbases included in the simulation. CT37/66 permits the user to specify a unique one-to-ten step UXO removal procedure for each type of munition, and CT37/77 can be used to specify a different (one-to-ten step) repair procedure for up to ten different runway crater sizes. The user is able to specify a different taxiway crater repair procedure for each base using CT37/88. CT37/99 is used to designate the manual mine removal procedures and the mine sweeping procedures to be used on runways and taxiways at each airbase; the manual removal procedures are interpreted in TSAR as the requirements to remove ten mines by hand, and the sweeping procedure times are interpreted as those required to clear 1000 ft of runway or 1000 ft of taxiway.

The entries on each of these special CT37 are the numbers of civil engineering tasks whose resource requirements are entered into the CERQTS array with CT38. For UXO removal, runway crater repair, and taxiway crater repair, the complete repair

procedure may consist of from one to ten sequential civil engineering tasks, and for any crater repair procedure the user may designate that the subsequent step can be started as soon as the preceding step has been started. Furthermore, since an alternate set of task resources may be specified for each CT38 procedure, the user is able to indicate alternate (normally slower) ways to carry out any or all steps of a complete repair procedure. Although mine removal involves only one-step procedures, these procedures may be unique at each base, and each of the designated procedures may have any number of alternate procedures defined by the CERQTS data (CT38).

It should be clear that the weapon cratering characteristics specified in the TSARINA input data must be coordinated with the CT37/77 entries for TSAR. Since the CT37/77 entries are organized during initialization such that the procedure selected in TSAR for runway crater repair will be that procedure specified for the crater radius closest (in feet) to the actual radius, one can use various crater sizes in TSARINA to control the repair procedures that will be used in TSAR. One consequence is that one may specify different runway crater repair procedures at different airbases for essentially the same size craters. This could be done, for example, by specifying one set of TSAR crater repair procedures for craters with 15-, 30-, and 45-ft radii, another set for craters with 14-, 29-, and 44-ft radii, and a third set for craters with 16-, 31-, and 46-ft radii; and then being careful to specify the first set of crater radii in TSARINA inputs for the first base, the second set for the second base, and the third set for the third base. In this way one would specify a different set of repair procedures at each of three airbases for essentially the same size runway craters. One must also coordinate TSARINA weapon types with the weapon-type entries on the CT37/66. (Note that these weapon types are completely different from and independent of the weapon types loaded on aircraft in the TSAR simulation and defined on CT11.)

The entries on CT37/88 are for repairing a taxiway crater of 10-ft radius. If the base in question suffers (in TSARINA) taxiway craters of different size, the number of taxiway craters reported from TSARINA to TSAR will not be the true number, but rather the number of 10-ft radius craters whose surface area equals the area of the actual craters. The reader should consider this when entering the CT37/88 data for taxiway repair.

For each arc with mines to be cleared, TSAR selects the procedure that requires the fewer manhours for clearance, when manual and sweeping procedures are both possible. For manual mine removal, a separate task is generated to clear each ten mines,

possible. For manual mine removal, a separate task is generated to clear each ten mines, and the time for a runway or taxiway sweeping task is based on the actual length of the segment being swept. If resources are not available for the preferred (lower manhour) procedure, the other (higher manpower) procedure is selected if the required manhours with the higher manpower procedure are no greater than FACTOR/10 times the manhours of the lower manpower procedure; FACTOR is the number entered in columns 31–35 or 36–40 on CT37/99 (the default values for FACTOR are 20). If neither procedure can be initiated, TSAR considers whatever alternate procedure(s) has been listed for the preferred (lower manpower) procedure.

The user will sometimes want to specify that all mine clearing resources (both manual and sweeping) are to be used to full capacity as long as there are still mines to be cleared. This is done by setting both FACTOR values to 10000. Make the alternate procedure for sweeping, the manual procedure, and vice versa, for both runway and taxiway mine clearance. If the sweeping or manual procedures already have alternates, make the alternate to the last sweeping alternate procedure, the primary (CT37/99) manual procedure, and vice versa, for both runway and taxiway work.

Sample Data

The #37/66 cards indicate that UXO Types #1 and #2 each require a three-step procedure to remove; procedures #1, #31, and #32 for the Type #1 UXOs and procedures #1, #33, and #34 for Type #2 UXOs.

The #37/77 cards illustrate the repair procedures for three different sizes of runway craters; a two-step process for a 5-ft radius crater, and three-step procedures for 20- and 35-ft radius craters.

A two-step process is to be used to repair taxiway craters at Base #1, as indicated by the #37/88 card.

The mine clearing instruction for Base #2 (CT37/99) indicates that sweeping (procedure #2) will always be used on runways, whereas manual mine removal or sweeping are to be used on taxiways, depending upon which requires the fewer manhours.

Card Type #38

01 02 Card Type	Task Type	Time Per Unit (Min)	Time Fnct	Personnel #1 Type	Personnel #1 No.	Personnel #2 Type	Personnel #2 No.	Equipment #1 Type	Equipment #1 No.	Equipment #2 Type	Equipment #2 No.	Material #1 Quan	Material #1 Type	Material #2 Quan	Material #2 Type	Alternate Procedure	Heat Factor MVDC	Heat Factor KCAL	Fraction Personnel Casualties * 1000	Fraction Casualties Fatal * 1000	Percent Equipment Irreparably Damaged Equipment #1	Percent Equipment Irreparably Damaged Equipment #2	Night repair time (percent)
38	1	30	48	192	4			196	1										100	600	10		
38	2	30	48	191	4	196	1	195	1										100	600	10		
38	3	30	48	191	2			197	1														
38	4	120	48	191	8	192	4	194	2	197	1	1	2										
38	5	180	48	191	19	192	6	194	1	197	2	1	4			7							
38	6	25	48	191	2	196	1	195	1														
38	7	330	48	191	10	192	2	197	1														
38	12	45	58	194	8			198	2	199	1	4	3	3	2	0	5	37					

The resources required for civil engineering reconstruction are defined on these cards. Each Task Type entered on CT37 must have a corresponding CT38 that defines the resource requirements for that procedure (these data are stored in the corresponding column of the CERQTS array). The characteristics of civil engineering procedures include a time, one or two teams of personnel, one or two sets of equipment, and one or two quantities of material. The user may also specify an alternate procedure, a heat factor, and the losses to be expected each time the procedure is carried out; the latter include the fraction of the personnel that work on the procedure that are casualties (× 1000), the fraction of the casualties that are fatal (× 1000), and the percent of each type of equipment that is irreparably damaged (reparable damage may be implied with the CT10 equipment repair data). Since many civil engineering procedures are hazardous, especially those dealing with UXOs and mines, these latter CT38 entries permit these considerations to be included in the simulation. And since many civil engineering tasks take longer at night, the final entry on CT38 permits the user to specify the repair time at night as a percent of the nominal repair time (currently night is interpreted as 1900 to 0500).

Since the interpretation for several of the CT38 entries differ for the repair of structures and for restoring runways and taxiways to operational status, they will be discussed separately.

Runway and Taxiway Clearance

Runways and taxiways are restored to operating condition by sequentially removing the UXO, and then the mines, and then repairing any bomb craters. The numbers of the civil engineering task procedures for these activities on a runway or

taxiway are to be entered with the Special CT37 cards: CT37/66, CT37/77, CT37/88, and CT37/99. UXO removal procedures may be specified for each type of munition, runway crater repair procedures for ten sizes of craters, and taxiway crater repair procedures for each base; each of these procedures may involve up to ten sequential steps, with the entries for each step on the Special CT37 cards referring to civil engineering procedures defined with CT38. The time function (cols. 14–15 on CT38) is inoperative for clearance tasks, except as noted below.

The procedures entered on the CT37/99 cards for manually clearing mines on runways and taxiways are interpreted as the time and resources needed to clear ten mines with teams that pick them up individually. Since the observed times for manually clearing mines can depend both on the number of mines and on the area over which they are scattered, the entry in the "Time per Fnct" column can be used to increase the specified time to account for the area that must be searched for mines. That entry is interpreted as the number of thousands of square feet that can be searched for mines, per minute, along a 100-ft-wide surface. Thus, if the entry in cols. 14–15 is "2," the time to manually remove ten mines on a 500-ft length of 100-ft-wide taxiway is increased by 25 min ($500 \times 100/2$).

When procedures are specified for sweeping mines from large sections of a runway or taxiway, the resources and times specified on CT38 for these sweeping procedures are assumed to be adequate for sweeping 1000 linear ft of surface. When mines are to be removed from a segment of a runway or of a taxiway, the procedure requiring the least manhours is selected if sufficient resources are available.

The procedures on CT37/88 for repairing taxiway craters are for a crater radius of 10 ft. If a crater of 20-ft radius were incurred in TSARINA, four repairs would be needed in TSAR to remove it (i.e., TSARINA would report four craters on that arc).

Note also that an alternative procedure may be entered on CT38 for any of these runway and taxiway clearance procedures; typically one would enter the characteristics of procedures that were somewhat less efficient but demanded fewer critical resources.

Sample Data for Runway Taxiway Clearance

Civil engineering repair procedure #1, specified on CT37/66 as that used for the first step for removing UXO, indicates that four Type #192 personnel working with a Type #196 equipment can accomplish the task in 30 min; similarly, procedure #2 indicates that four Type #191 people and a Type #196 person using a Type #195

equipment (presumably a sweeper) can sweep 1000 ft of runway in 30 min. Ten percent of the personnel working on either procedure #1 or #2 are casualties, and 60 percent of these casualties are fatal; 10 percent of the equipments used are also irreparably damaged. Procedure #3 uses two Type #191 personnel and a Type #197 equipment for 30 min to pick up ten mines on taxiways; a sweeper would be used with procedure #6 if fewer manhours would be required to clear all the mines that are present.

The first step of a 20-ft radius runway crater repair (procedure #5) takes three hours using 19 Type #191 and 6 Type #192 personnel, 2 Type #194 and 2 Type #197 equipments, and 1 unit of Type #4 building materials; if these resources are not available, procedure #7 provides another method for the first step of the repair that requires fewer men and equipment, and no building materials, but takes 2.5 hours longer.

Structural Repair and Reconstitution

The materials required for structural repair of all facilities other than the runways and taxiways is assumed to be proportional to the total damage that was sustained; the time required for the repair is related to the damage in a more complex fashion, as will be explained. The time and material requirements specified on this card are the requirements for one size-unit of reconstruction, where the total damage or required reconstruction is defined as the "percent damage" (reported from TSARINA) times the building "size" specified on CT37. The largest quantity of material that may be entered for a unit-task is 320.

When a facility may require a sequence of two or more repair procedures for it to be restored to an operational status (as indicated by a positive entry in columns 21–30 or 61–65 of CT37), the time and resource requirements for each procedure are determined on the basis of the damage stored in the DAMAGE array for each building or procedure. When no damage has been reported, as would be normal for subsequent procedures, it is assumed the percent damage for all steps in the repair sequence is the same.

As with runways and taxiways, an alternative repair procedure may be specified for any of the structural repair procedures defined with a CT38 card. Since the number of such a procedure defines the column in the CERQTS array where the data will be stored, the user may not enter more procedures than that array's dimension (NOCE) permits.

The dependence of the time for structural repairs on the total damage can take several functional forms. These user-specified relationships permit the task time to be

expressed as the sum of a start-up time and a damage-dependent time. The total time needed to repair any number of units of damage is:

$$T = \text{Start-up}(B) + (\text{Repair time/Unit damage}) \times (\text{Units of Damage})^{g(P)}$$

where

$$\text{Start-up}(B) = 0,1,2,3,4,6,8,12,18,24,36,48 \text{ hours for } B = 1 \text{ to } 12$$

and

$$g(P) = 0.5, 0.75, 0.9, 1.0, 1.1, 1.25, \text{ and } 1.5 \text{ for } P = 1 \text{ to } 7$$

The user chooses values of B and P with entry of parameter "C" as the FUNCtion, where:

$$C = 12 \times P + (B - 1)$$

The FTIME Function translates the user-specified value for C (cols. 14–15 on CT38) into the total time required.

Sample Data for Structural Repair

The last sample #38 card describes the Type #12 procedure for structural reconstruction jobs. This procedure uses eight Type #194 personnel, as well as two Type #198 and one Type #199 equipment. Four units of building material Type #3 and three units of Type #2 are required per unit of damage. The time per unit of construction is 45 min and varies as a function of the amount of reconstruction as specified by function FTIME #58; i.e., if 40 percent damage were sustained by a facility that is 60 units in size, the total time for reconstruction would be

$$720 + (45/3) \times (.40 \times 60)^{1.0} = 1080 \text{ TTU}$$

or 54 hours (since P = 4 and B = 11 when C = 58). For this same level of damage, the repair would also require 96 units of Type #3 material and 72 units of Type #2 material. When protective ensembles are worn, this nominal task time is increased by the factors appropriate for a MVDC = 5 and the time that a particular crew can work is based on a metabolic heat generation rate of 370 KCAL/hour.

Card Type #39

RECONSTRUCTION PRIORITIES

Card Type	Base	I^{th} Priority	Facilities Ordered by Reconstruction Priority – CEPRTY ARRAY – I^{th}	$I^{th}+1$	$I^{th}+2$	$I^{th}+3$	$I^{th}+4$	$I^{th}+5$	$I^{th}+6$	$I^{th}+7$	$I^{th}+8$	$I^{th}+9$
39		1	46	48	40	36	2	1	9			

Card Type		Base	Additional Personnel Loss Rates for Conventional Attacks: On-Equipment Assigned	On-Equipment Unassigned	Back-Shop	Munitions Assembly	CE Tasks	Off-duty
39	99							

The CT39 cards specify the reconstruction priorities for all on-base structures that may be repaired, but do not affect work on runways or taxiways. Each on-base facility (including all members of any distributed facility, but exclusive of "building" numbers used to define a sequence of tasks) must be entered[6] in this priority list if their repair is to be contemplated. Facility #36 implies the repair of damaged aircraft shelters.

Facilities #37 through #39 have been set aside for internal use and must not be included in this list. Runways and taxiways have top priority for civil engineering resources, but the priorities for reconstruction of the other reparable facilities must be prescribed with these CT39.

When the postattack delay for runway and taxiway repairs is complete, those repairs are initiated, to the extent permitted by the available resources, with a call to subroutine REBILD. When the delay for other civil engineering tasks is complete, another call is made to subroutine REBILD to initiate that work. In the latter instance TSAR first tests whether the remaining civil engineering resources are adequate to repair all damaged facilities with a priority higher than that for facility CRBLDG (CT17/3). If the resources are available, all work is started; if they are insufficient, resources for the first alternative repair procedure for all damaged facilities (when specified), or alternatives thereto, are allocated to each damaged facility until all available civil engineering personnel and equipment are assigned. By specifying fewer resources and

[6]The only exceptions to this rule are for "duplicate" facilities, i.e., when two or more functions are carried out in the same building. In that case, only the facility corresponding to the first of the collocated functions needs to be repaired to restore all the functions, hence only the first facility needs to be listed with the CT39. If the others are listed, they must appear later in the list, but this has no effect on the simulation.

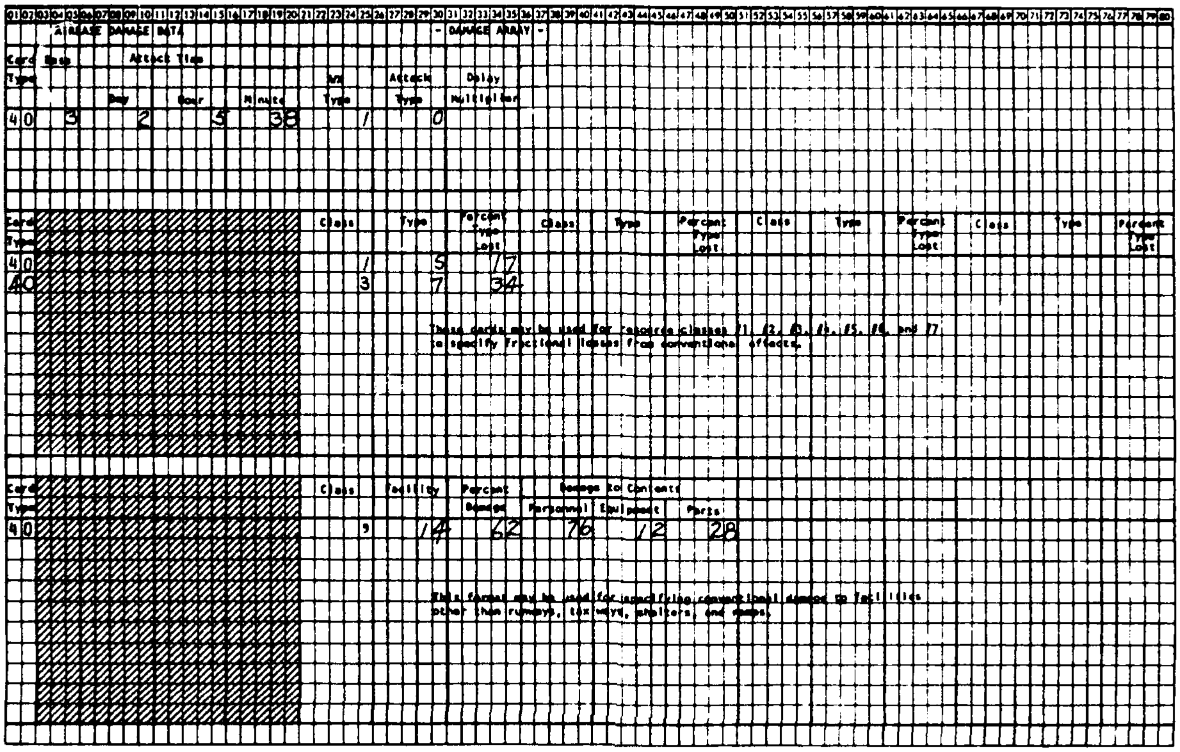
longer times for the alternative repair procedures, this use of CRBLDG results in the available work force being assigned to a larger proportion of the higher priority tasks.

The CT39/99 card can be used to specify casualties over and above those specified by TSARINA computations; such additive losses may be prescribed for six different subsets of personnel at each base. The base number is entered in the first data field, and the percentage losses are entered in fields two through seven for (1) assigned on-equipment personnel, (2) unassigned on-equipment personnel, (3) backshop personnel, (4) munitions assembly personnel, (5) civil engineering personnel, and (6) off-duty personnel.

Sample Data

This card specifies the priority for structural repair of facilities. If damaged, facilities #46, #48, #40, etc., should be worked on first, then aircraft shelters (facility #36), then facilities #2, #1, and finally #9 should be worked on. This ordering of priorities will be applied at all bases, since no base number has been specified.

Card Type #40



In general, these cards should be generated by TSARINA rather than being prepared manually as was practical with the early version of TSAR. The range of data that are now entered with these cards is substantially greater, and their organization substantially more complex, than in the earlier versions of TSAR. CT40 should be considered for manual data entry only when the user wishes to represent the simpler types of damage from conventional attacks. Manual entry should not be considered for representing damage to aircraft in shelters, to taxiways or runways, or for any of the effects of chemical attacks.

Manual entry of damage data with CT40 cards is straightforward for specifying loss rates of specific types of personnel, equipment, spare parts, munitions, TRAP, building material, and POL, and for indicating the level of damage to specific buildings and to the personnel, equipment, and spares that might be in those buildings at the time of the attack. If the user also wishes to enter damage estimates for aircraft on parking ramps or for aircraft that are taxiing, or wishes to include the effects of attacks by ground forces, the necessary instructions are in App. J of Vol. III.

The order in which data are entered on user-prepared CT40 cards is significant. An attack is denoted by entering the location and time of the attack in the "J" field and in the next three fields; the attack type in field five should be specified as 0, unless the additional capabilities described in App. J are to be used. The meteorological condition may be changed with an entry in the fourth field. If the delay multiplier is not zero (or null), the SHPDLY and CEDELY (CT4/1) are multiplied by one-tenth the value of the multiplier. All subsequent CT40 cards are associated with the same attack until another entry is encountered in the "J" field.

The percent losses experienced by a specific class and specific type of resource may be specified using these cards; however, if the user wishes to assume that all members (or all *unmentioned* members) of a given class sustain the same loss rate, the "type" number should not be entered; when that is done, all members of a class suffer a common loss rate. These procedures may be used for the first six classes of resources; for these damage data only the class, type, and percent loss should be entered. For buildings and other facilities, the loss rate entered in columns 31-35 is interpreted as the percent damage to the structure itself. In addition, loss rates may be entered that express the percentages of the personnel, equipment, and parts in the facility that are lost in the attack.

Sample Data

These several cards specify the damage inflicted on Base #3 by an attack at 0538 on day 2. The first card indicates a conventional attack (ATTYPE = 0). The second and third cards specify that 17 percent of the Type #5 personnel are casualties and 34 percent of the Type #7 parts are lost.

The fourth card indicates that building #14 sustained 62 percent damage and that 76, 12, and 28 percent of the personnel, equipment, and parts, respectively, that are present at the time of the attack would be lost.

INITIALIZATION OF AIRCRAFT AND SHOP STATUS

Card Type #41

AIRCRAFT STATUS INITIALIZATION

Card Type	Base No.	AC Type	No. Assigned by Mission 1	2	3	4	5	AC Type	No. Assigned by Mission 1	2	3	4	5	AC Type	No. Assigned by Mission 1	2	3	4	5	AC Type	No. Assigned by Mission 1	2	3	4	5	AC Type	No. Assigned by Mission 1	2	3	4	5
41	1	1	12	12																											
41	2	1	12		12																										

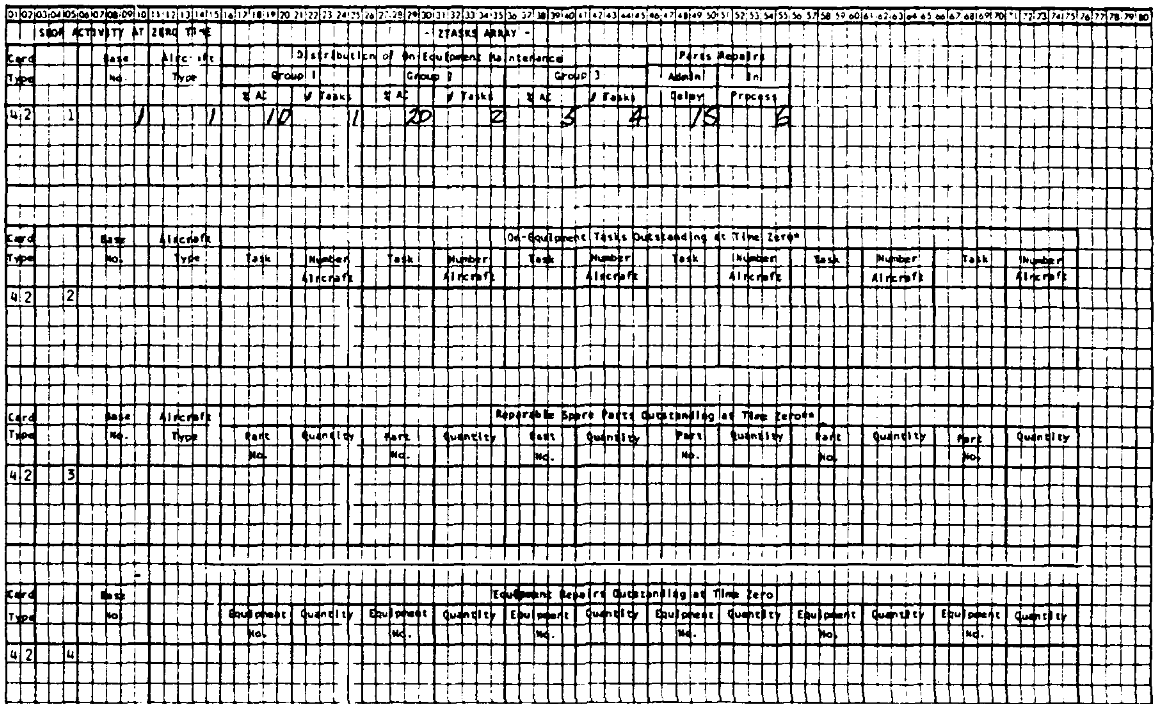
TSAR default assumptions initiate the simulation with the aircraft and shops in the conditions that might be expected if war were to break out following a period of warning and a· ·t. All aircraft are ready to be launched on specified missions, fully loaded with the preferred standard combat load and *configuration for those missions.* No aircraft maintenance tasks, parts repair, weapons assembly, or civil engineering tasks are in process, waiting, or interrupted. These latter conditions may be modified with CT42.

The CT41 cards specify the numbers of each type of aircraft that are ready for each of the several missions for each base. They must be entered after CT15, CT20, CT24, and CT25, and the bases and the aircraft types *must be entered in the same order as on CT20.*

Sample Data

This card specifies that at the beginning of the simulation half of the aircraft on each base are assigned to one of two missions; aircraft are configured for missions #1 and #2 at Base #1, and for missions #1 and #3 at Base #2. These data must be input in the identical base-aircraft order used with the CT20 cards.

Card Types #42/1, #42/2, #42/3, and #42/4



*Task numbers must be root segments that may be handled on-base.
**Reparable parts are limited to the number that are serviceable; will be NRTSed as appropriate.

These cards can be used in conjunction with CT41 to initialize aircraft maintenance activity at the beginning of the simulation. After CT41 has been used to specify that all aircraft are ready to be launched, these cards will modify those conditions. CT42/1 cards can be used to simulate on-going maintenance tasks that are selected at random. For on-equipment tasks, a three-part distribution may be specified. Each part is defined as a fraction of a given type of aircraft at a particular base, and a number of tasks; thus, one might specify that 10 percent of the aircraft have one unscheduled task to be completed, 20 percent have two tasks, and 5 percent have four tasks. At initialization, a random number is drawn for each aircraft to see if work remains, and how much. If work remains, tasks are selected at random, in proportion to their probability of occurence; when a task is selected, the time remaining to completion is taken as a random portion of the total task time when it can be started; otherwise it must wait.

The user may also specify a level of parts repair activity with CT42/1. Two numbers can be input for each aircraft type and base; the first is the number of repair

tasks to be placed in the administrative delay, and the second is the number to be placed in-process or waiting. These activities are selected in proportion to their probability of occurrence, and the portion of the time remaining is selected randomly. Whether a task is in-process or waiting is determined by the availability of the required personnel and equipment.

It is also possible for a user to designate particular tasks and parts and equipment repairs that may be known to be chronic problems at an airbase. These capabilities for specific tasks are controlled with the CT42/2, CT42/3, and CT42/4 cards. Since on-equipment tasks may use parts and equipment, and parts repairs may use SRUs and equipment, the numbers of parts and equipment that are available to be placed in a reparable state by using these card types will be influenced by the other tasks and repairs that are specified as outstanding at zero time. The user controls the priority of these specific tasks, parts repairs, and equipment repairs by the order in which the CT42/2, CT42/3, and CT42/4 cards are inset; these cards may be entered in any order as long as there is at least one pair of entries on each card. The ZZTSK array is dimensioned so that up to 50 sets of tasks, parts repairs, and equipment repairs may be specified as outstanding at time zero.

Sample Data

This card image indicates that Type #1 aircraft at Base #1 should be assigned ongoing maintenance activity at zero-time according to the distribution discussed above. This card also directs that 21 on-base parts repair jobs are to exist at zero-time—15 in the administrative delay queue and 6 in process or waiting for resources to be started.

SIMULATION OF THE EFFECTS OF CHEMICAL WARFARE

Card Type #43

Several CT43 cards are used to specify the various data needed to simulate the effect of the chemical protection ensembles that interfere with the effective conduct of tasks, and that can cause an excessive buildup of heat in the body and/or excessive perspiration or dehydration that can force support personnel to rest and cool down after a task has been completed or interrupted. There are eight subtypes for CT43.

CT43/1, shown in Fig. 12, provides data needed to define the heat transfer properties of the various ensembles. The various portions of a particular type of ensemble that must be worn under different circumstances are identified by a consecutive set of numbers, known as MOPP. The least amount of the ensemble that would be worn is identified with the lowest MOPP number, the "Low Mopp Limit" on CT3/4 and CT3/7; the complete ensemble that would be donned at the time of an attack, and worn until possible contamination has been checked, is identified by the highest MOPP number, the "Full MOPP Limit" on CT3/4 and CT3/7.

The four data input with CT43/1 include the nominal (at rest) skin temperature when each MOPP is worn, the pumping factor (γ), the insulation factor (CLO), and the permeability factor (IM). The skin temperature should be in tenths of degrees Centigrade (if a minus value is entered it will be interpreted as tenths of degrees Fahrenheit). The last three factors are defined in an article by Berlin, Stroschein, and Goldman,[7] and in the introduction to subroutine CKTEMP (check temperature). Input data are required only for MOPPs that will actually be worn in the simulation; this is controlled by other data entered with the CT44/4 cards. Only 14 MOPP numbers may be defined, in total, for the three ensembles.

CT43/2 permits the user to define several different meteorological conditions that can be used during the simulation. Storage provisions currently are provided for 20 different environments, any one of which can be specified at a particular base in the TSAR analysis and may be changed at the time of each attack (see CT17/1, CT40, and CT49). If all analyses are to be conducted with the same meteorological conditions—for example, a spring day in Europe—only the single set of meteorological conditions need

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[7]H. M. Berlin, L. Stroschein, and R. F. Goldman, *A Computer Program to Predict Energy Cost, Rectal Temperature, and Heart Rate Response to Work, Clothing, and Environment*, ED-SP-75011, Edgewood Arsenal, Aberdeen Proving Ground, Maryland, November 1975.

HEAT GENERATION FACTORS — VALUES ARRAY —

Card Type		Factor (i)*	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14
							MOPP									
43	1	1	350	350	350	350	360									
43	1	2	250	250	250	270	200									
43	1	3	1700	1650	2240	2160	2650									
43	1	4	470	440	330	240	280									

METEOROLOGICAL CONDITIONS — CWMET ARRAY —

Card Type		Met Type	Met Factor (i)**	0–2:00	2:00–4:00	4:00–6:00	6:00–8:00	8:00–10:00	10:00–12:00	12:00–14:00	14:00–16:00	16:00–18:00	18:00–20:00	20:00–22:00	22:00–24:00
				Time Block											
43	2	5	1	-57	-58	-62	-66	-69	-73	-75	-74	-68	-64	-62	-60
43	2	5	2	85	80	78	73	64	58	56	57	57	66	76	78
43	2	5	3	20	22	24	30	32	34	27	20	16	14	18	20

TASK TIME SLOW-DOWN FACTORS — SLOWDN ARRAY —

Card Type		MVBC Condition	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14
							MOPP									
43	3	1	110	131	131	131	131*									

*(Tasks times as a percentage of shirt-sleeve time)

*Factors
1 = Skin temperature (°C)
2 = Gamma - the pumping factor x 1000
3 = CLO - Insulation factor
4 = IM - permeability factor

**Factor No.
1 = Ambient temperature (°C)
2 = % humidity
3 = Wind velocity (m/s x 10)
4 = Vertical stability

Fig. 12—Heat effects of CW ensembles

be input. The data that are required include ambient temperature, percent humidity, and wind velocity. These data are provided for a 24-hour period in two-hour increments running from midnight to midnight. For ambient temperature, the expected input is in degrees Centigrade; however, if it is preferred to specify the temperature in degrees Fahrenheit, a negative value will be interpreted as degrees Fahrenheit (i.e., freezing weather, obviously, is prohibited). Wind velocity should be expressed in tenths of meters per second.

Sample Data

The characteristics that determine the effectiveness with which excessive heat can be dissipated are indicated with the CT43/1 cards for MOPP #1 to #5. MOPP #1 is used here to refer to fatigues; the mask, hood, and gloves worn with fatigues is defined as MOPP #2; the chemical protective suit worn unzippered over the fatigues and without mask, boots, or gloves is MOPP #3; MOPP #4 is the zippered-up suit worn with mask, hood, and gloves but without fatigues; while MOPP #5 is MOPP #4 worn with the fatigues. For the first four MOPPs, the effective skin temperature is taken to be 35°C, and 36°C for MOPP #5; the pumping factor (γ) ranges from 0.200 to 0.270, the insulation factor (CLO) from 1.70 to 2.65, and the permeability (IM) from 0.476 down to 0.240.

Meteorological state #5 has a temperature range from 57°F just after midnight to a high of 75°F between noon and 14:00. The humidity falls from the high of 85 percent just after midnight to the low of 56 percent, and the wind velocity near the ground ranges from 2.0 m/sec at midnight up to 3.4 m/sec and back down to 1.4 m/sec.

Card Type #43/3

CT43/3, shown in Fig. 12, specifies the effect of various chemical protection postures (i.e., various MOPPs) on the mobility, visibility, dexterity, and communication (MVDC) capabilities of maintenance personnel in the conduct of their tasks. The extent to which the ensemble interferes with and impedes a given task is expressed in TSAR as a percent increase in the time required to carry out the task. That is, the value of 150 for a particular MOPP would imply that the task would require 150 percent of the nominal time when that MOPP is worn; the time that would be required for the work team to cool off after the task is complete would be an addition to the lengthened task time.

The data entered with CT43/3 are used in conjunction with the "heat factor" data that can be input for each individual task type, and for which default values are provided

for each of the five generic task types with CT3/5. The "heat factor," as it is called in TSAR, is actually composed of two numbers. The first is the MVDC for the task, and the second is the metabolic heat generation rate for the task. Each task in TSAR is thus associated with an MVDC condition, and the percent increase in task time that occurs when the various MOPPs are being worn is defined for each MVDC condition with CT43/3. Up to 50 MVDC conditions may be defined. If the default heat factors (see subroutine INPUT) are used, 5 MVDC conditions must be defined. Thus, for example, when the heat factor for a given task is specified as 1532, MVDC condition #15 (the integer part of (Heat Factor)/100) is to be used to determine the slow-down factors for the several MOPPs; the "32" specifies that the metabolic heat generation rate for that task is 320 kilocalories per hour.

Sample Data

This card specifies how task time degradation varies with the MOPP for MVDC condition #1. For this MVDC, tasks will take 110 percent of the normal time in MOPP #1 and 131 percent of the nominal time in the other MOPPs.

Card Types #43/4 and #43/5

One of the main causes of casualties due to chemical agents is that personnel may be wearing an inappropriate MOPP at the time of an attack. The preattack MOPP (specified for each generic task type on CT3/4 and CT3/7) is the MOPP that is to be worn prior to air attack when personnel are in chemical-free conditions, but when a chemical attack must be expected. In the simulation, the time to change from the preattack MOPP to full MOPP (the MOPP that is to be worn during an attack) is compared with the warning time (i.e., the time from the moment in the attack at which the dispensers release the chemicals until personnel are notified of the attack) to determine whether the personnel at each location have had sufficient time to don the appropriate MOPP. If not, the personnel have a greatly increased chance of receiving serious toxic effects. The first of the two CT43/4 shown in Fig. 13 is used to enter the average time (in minutes) for support personnel to change from one MOPP to the ensemble that is to be donned when an attack is imminent or has occurred. The second CT43/4 is the average time (in seconds) that it takes personnel in any particular MOPP to don a mask before getting into any other required parts of the ensemble. If the mask is already on in a particular MOPP, the appropriate entry is zero (or null) on the second CT43/4.

CT43/5 enters the distributions of hospitalization times that are to be applied to those personnel who must be hospitalized because of heat prostration from heat buildup while working a task, or because of injury from conventional attacks, or because of the toxic effects of chemical attacks. In each case the distributions are expressed as the average hospitalization time in hours for the 10 percent that require the least hospitalization, for the 10 percent that require the next least hospitalization, etc., up to the time required for the 10 percent that require the longest hospitalization. Distribution #1 is applied to heat prostration victims, and distribution #2 is applied to casualties from conventional attacks. Distribution #3 is for victims of the more serious toxic effects of chemical agents; the less serious ocular effects are not presently evaluated in TSAR.

Sample Data

These CT43/4 specify that it takes an average of 20 min to get into the full chemical ensemble—i.e., to change from MOPP #1 to the full ensemble (MOPP #5) for ensemble #1. Only 4 or 6 min are required when the personnel are already attired in MOPP #2 or #3. Donning the mask is to be assumed to take an average of 15 sec.

TIMES TO CHANGE FROM PARTIAL TO FULL MOPP — MOPMOP ARRAY —

Card Type	Policy		Prior MOPP #1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14
43	4	1 (Suit)	(Time in minutes to get into full MOPP)													
		2 (Mask)	(Time in seconds to put on mask)													
43	4	1	20	4	6	0	0									
43	4	2	15	6	15	0	0									

HOSPITALIZATION TIMES — CURE ARRAY —

Times for 10 (10) 100 Percent Recovery (Hrs)

Card Type		Cause 1, 2, 3, or 4***	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	80 - 90	90 - 100
43	5	1	24	28	34	40	48	60	78	86	98	120

COLLECTIVE PROTECTION FACILITIES AND ENTRY TIMES — PROTEC ARRAY —

Card Type		Base	Flight Line 1st CPS	Flight Line Entry Time (Min)	Flight Line D	Back Shops 1st CPS	Back Shops Entry Time (Min)	Back Shops D	Munitions Assembly 1st CPS	Munitions Assembly Entry Time (Min)	Munitions Assembly D	CE Tasks 1st CPS	CE Tasks Entry Time (Min)	CE Tasks D
43	6	1	121	24	6	123	30	6	121	15	6	125	18	6

***Cause:
1 = Heat prostration
2 = Conventional
3 = Toxic agents
4 =

Fig. 13—Don times, hospitalization times, and collective protection

The CT43/5 indicates that 10 percent of those personnel who collapse from heat prostration can be expected to return from the hospital for duty in 24 hours, the next 10 percent are available after 28 hours, the last 10 percent of these casualties will be off duty for 120 hours.

Card Type #43/6 (Collective Protection Shelters)

CT43/6, shown in Fig. 13, permits the user to specify sets of facilities that are to be used for personnel who have finished a task and must cool off before they can return to productive work. Sec. IX.6 provides a full discussion of the several options the user has for controlling the use of collective protection shelters (CPSs).

The default condition in TSAR assumes that when personnel have worked until they must stop because of the buildup of heat, they stop and cool off where they were working. If they are working on the flight line, it is assumed they must cool off there as well. Similarly, if they are in a shop, that is where they cool off. Civil engineers stay out in the open where they have been working to cool off. When the variable USECP (use collective protection—see CT3/4) is initialized, special collective protection shelters will be used for personnel to cool off when such shelters have been specified with CT43/6. For each of the four generic task types shown on the sample data card, the user may specify distinct groups of facilities as CPSs. The shelters for the four generic task types may be the same for all types, or may be a separate group of shelters for each generic task type.

The first of each such group of shelters is specified in the left-hand field under the appropriate generic task type. Descriptive data for each of the CPSs in each group must be entered with CT37. The several members of a group are defined with CT37 in the same manner that a distributed shop capability is defined; the relative capacity of each of these CPSs must also be indicated with CT37 (i.e., with a number less than 50). The facility number for all of these CPS locations must be chosen in the range 51 to NOFAC, and no facility can be associated with more than one group of CPSs (when two or more sets of personnel share a particular building, two or more TSAR "facilities" may be designated in TSARINA that have identical characteristics—i.e., are the same building).

In the case of the flight-line personnel—either unscheduled maintenance or preflight tasks—there is an additional option. If no facility is specified on CT43/6 for collective protection, but USECP is greater than zero, the personnel will be sent to the designated assembly location for personnel of the appropriate squadron. Thus, personnel

in squadron #2 would go to facility #32 to cool off. Or if facility #32 has been specified as a distributed facility with a CT37, then the personnel would be sent to one of these facilities based on its relative capacity.

To recap, whenever personnel stop work on one of the generic task types and must cool off, they either cool off at their work place or select one of the group of CPSs that has been specified for that generic task type; the CPS is selected at random from the group based on relative capacity. When a CPS is selected, the time for cooling off is equal to the cool-off time that is computed for the existing conditions in that facility, plus an additional entry time and queuing time. When USECP = 1 or USECP = 2, entry time is the time specified (in minutes) on the CT43/6 cards, and queuing is ignored. When USECP = 3 or USECP = 4, entry time is that specified (in tenths of minutes) on the CT37 cards for the individual facilities; and the entry queue is simulated at each CPS taking into account the entry time and the number of individuals that may enter simultaneously. (If no entry time is entered for a facility on a CT37 card, and USECP > 2, it is assumed that only one individual may enter at a time and that his entry time is that specified on CT43/6.)

Whenever USECP > 0, the user-specified distribution of the entry time (on CT43/6) is taken into account in determining the realized entry time. When USECP = 1 or 2, it is used to modify the entry time, and when USECP = 3 or 4, it modifies the individual entry times. Several additional options[8] are available when a distribution

[8]Additional options available when USECP = 1 or 2 make it possible to vary the entry time in such a way as to simulate an occasional extended period in the collective protective shelter to eat or satisfy other bodily functions. This behavior is obtained when the distribution specified for the entry delay is ≥ 20; when that number is formed from the two digits x and y (where $20 \le xy \le 99$), the nominal delay (i.e., entry time) will be imposed on $(x - 1)/x$ of the events, and it will be y times longer on $1/x$ of the events. Furthermore, when the user wants to simulate that this extended delay takes place in a particular collective protection shelter, the variable REMOTE in the seventh field on CT3/5 should be set to unity, and the personnel sustaining this delay will be sent to the first of the distributed set of collective protection shelters for that generic task type. If that shelter is off base or at some other remote location that would be used only when the delay is long, the "capacity" of that shelter should be set to zero so that it will not be picked except when the delay is long.

Another option is provided when $xy \ge 20$ and $y = 0$; in this case a collective protection shelter will be selected for $1/x$ of the events and the basic entry time will be applied; for the other events, the team will cool off at the task location and there will be no additional "entry time." A somewhat different option is invoked when a negative number is entered for the collective protection facility. When this is done and a distribution xy (where $20 \le xy \le 99$) is entered, the team will cool off at the task location

number equal to or greater than 20 is specified, as is explained in detail in Sec. IX.6; some are available when USECP = 1 or 2, and others when USECP > 2.

Sample Data

The flight-line and munitions assembly personnel at Base #1 share one set of collective protection shelters while the backshop personnel and the civil engineers each have their own facilities. The entry time for flight-line personnel averages 24 min, ranging from about 14 to 34 min (distribution #6); the other groups have average entry times that range from 15 to 30 min.

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after $(x - 1)/x$ of the tasks, and a collective protection shelter for $1/x$ of the tasks. The time added to the computed cool-off time at the work location is the "entry time," and it is y times as long at the CPS, when $y \neq 0$ (when $y = 0$ this option is the same as the preceding option for $y = 0$).

When USECP > 2 and a distribution ≥ 20 is specified, a CPS is selected only for $1/x$ of the tasks; the personnel cool off at their work place in all other cases. If $y = 0$ only the queuing time and the processing time are added to the cooling time when a CPS is selected; but when $y > 0$, an additional delay equal to the "entry time" on CT43/6 is added for a fraction $1/y$ of the events to account for the extra time for eating or attending to other bodily functions. In this latter case, all work crews that have this added delay will be assigned to the "1st CPF" if REMOTE = 1.

Card Types #43/7 and #43/8

DEHYDRATION, PERSPIRATION, AND WETTING CRITERIA

Card Type		RELAX Rest Time (Min)	MXHEAT (W/m²)	MXTLOS (W/m²)
43	7	60	50	2000

RECOMMENDED THERMAL CONSTRAINTS AND LIMITS - DOUBLE ARRAY

Card Type		Non-Acclimatized Personnel: Heat Buildup (Wh/m²)	Maximum Sweating (Resting) (W/m²)	Hydration Loss (Wh/m²)	Cutaneous Wetting Limits W_{MAX1}	Cutaneous Wetting Limits W_{MAX2}	Maximum Sweating (Working) (W/m²)	Acclimatized Personnel: Heat Buildup (Wh/m²)	Maximum Sweating (Resting) (W/m²)	Hydration Loss (Wh/m²)	Cutaneous Wetting Limits W_{MAX1}	Cutaneous Wetting Limits W_{MAX2}	Maximum Sweating (Working) (W/m²)
43	8	60	150	1250	850	500	250	60	300	2000	1000	850	400

CT43/7 and CT43/8 provide the factors used in checking the permissible time that personnel may work without sustaining excessive perspiration, wetting, or dehydration. (See Sec. IX.2, Vol. I.) These factors are only considered when NOVOGT is zero.

The formulation of permissible work times and required rest times incorporated into TSAR is expressed in terms of eight different thermal constraints or limits. For six of these factors, Annex 3 of the Draft Standard on Thermal Environments[9] presents different values for personnel who are acclimated to adverse working environments and for those who are not acclimated. CT43/8 is used for entering these six pairs of values. The number of days of acclimatization is entered on CT3/5. CT43/7 is used to enter the "heat buildup limit" (MXHEAT) and the "maximum thermal loss" (MXTLOS). The values for these various factors that are used subsequently in the sample problem are those recommended in the Draft Standard.

The rest time recommended by the Draft Standard on Thermal Environments is one hour for a task that must be stopped because of excessive heat buildup or excessive sweating, and the remainder of the shift when the dehydration limit is reached. There is no recommended rest time for tasks that do not require as long as that permitted by the limits. In TSAR the required rest time is taken to be a fraction (task time/allowable task time) of RELAX when the least allowable time is for excessive heat buildup or for

[9]*Draft Standard, Thermal Environments, Analytical Determination of Thermal Stress*, ISO/TC159/SC5/WG1, Working Group "Thermal Environments" of subcommittee 5 "Ergonomics of the Physical Environment," International Standards Organization, undated.

excessive sweating (where the standard recommends the value 60 min for RELAX). TSAR also estimates the rest time required because of dehydration as the fraction (task time/allowable task time)^2 of the entire 12-hour shift.

The rest time required for personnel that have finished or stopped a task is the largest of the values estimated (1) as necessary for the rectal temperature to fall to the required level, (2) as required because of excessive heat buildup or excessive sweating, and (3) as needed because of excessive dehydration. And the permissible work time is the smallest of the values imposed by the same three limits.

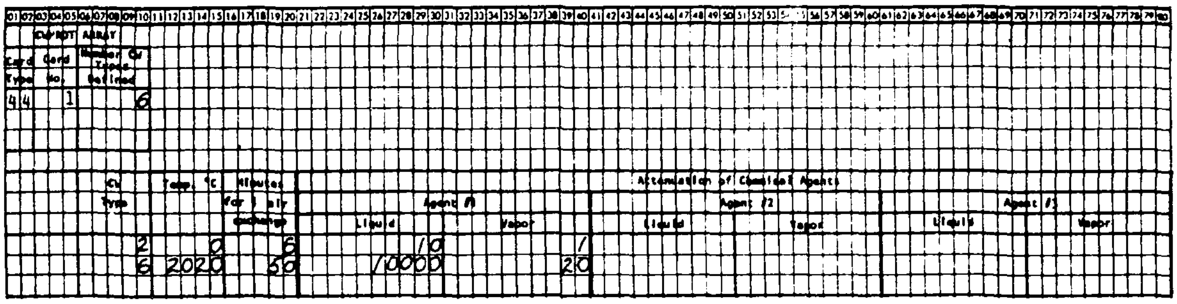
Sample Data

The values shown here and used in the sample problem in Sec. XX are taken from the recommendations offered in *Draft Standard, Thermal Environments*.

Card Type #44

The several types of CT44 cards provide data concerned with the chemical effects of the chemical environment (as distinct from the heat effects, that are entered on the CT43 cards).

Card Type #44/1 (Chemical Protection Characteristics of Facilities)



Facilities in TSAR belong to one of up to ten "CW Types"; CT44/1 defines the chemical protection properties of each CW Type. The designation CW Type #1 is reserved to refer to personnel in the open and CW Type #2 refers to personnel in aircraft shelters. The properties of up to eight other types of facilities may be associated with CW Type #3 through CW Type #10. The only data entered on a CT44/1 is the number of additional cards to be read immediately after CT44/1 has been read. An additional card is required for each CW type that is to be described; a special data format is used in reading these cards (I10, 2F5.0, 6F10.0).

Eight numbers are entered for each CW type. The first defines the temperature (degrees Centigrade) within the facility. Five options are available for entering the temperature conditions:

1. If the temperature is the same as the ambient temperature, enter 0.
2. If the temperature is held fixed at T °C, enter T.
3. If the temperature is held L °C below ambient, enter –L.
4. If the temperature is ambient, except that it may not exceed T °C, enter 100 + T.
5. If the temperature is L ° less than ambient, except that it may not fall below T °C, enter 200 × L + T.

The time in minutes for one air exchange of the air in the building and the outside is entered in the second data field. The six data that follow are (1) the filter attenuation of the first chemical agent in its liquid form, (2) the filter attenuation of that agent in vapor form, (3) and (4) the filter attenuation of the second agent in liquid and vapor form, and (5) and (6) the filter attenuation of the third agent in liquid and vapor form.

Sample Data

The 6 on the CT44/1 card indicates that six different sets of chemical protection characteristics will be defined on the subsequent six cards. Two are shown here, the second and sixth. The second card describes CW Type #2, which is reserved for aircraft shelters. The 0 in column 15 signifies that the inside temperature is equal to the outside ambient temperature, and the 6 implies that the air in the shelter is exchanged with outside air every 6 min. The next two numbers signify that the liquid phase of agent #1 is attenuated by a factor of 10 in the shelter, but that the vapor is not filtered, or attenuated, in any way. The other card, for CW Type #6, specifies that the temperature in the facility is maintained at 20°C, or 10°C less than the ambient temperature, whichever is *greater*, and that the air in the facility is exchanged in 50 min. The attenuation of liquid agent #1 is 10000 in this facility, and the attenuation of the vapor is 20.

Card Types #44/2 and #44/3

CWTP ARRAY

Card Type	Card No.	Ith Target Type	Chemical Protection Characteristics - CW TYPE - Ith TSARINA Target Type: I	I+1	I+2	I+3	I+4	I+5	I+6	I+7	I+8	I+9
44	2	11	3	1	1	1	3					

Card Type	Card No.	Agent No.	MOPP
44	3	1	3

AGENT ARRAY

Phase: Percutaneous Liquid = 1, Vapor = 2; Inhalation Vapor = 3	Fatalities: 50% Dosage	Stan. Dev.	Incapacitating Dosage: 50% Dosage	Stan. Dev.	Ocular Degradation: 50% Dosage	Stan. Dev.
1	10000	0.2	5000	0.2		
2	80000	0.2	40000	0.2		
3	50	0.2	25	0.2		

The CT44/2 card is used to specify the chemical protection properties that are associated with each of the target types designated in TSARINA. These target types, of course, refer basically to the structural characteristics of the facility, not the chemical protection properties. CT44/2 provides the means by which the 30 possible TSARINA target types have their chemical protection characteristics defined in terms of a CW Type number (between 1 and 10). These data are required for processing the TSARINA data that associates various percentages of each personnel type with different target types and monitoring points. It is mandatory that CW Type #1 be used for personnel in the open and CW Type #2 for personnel in aircraft shelters.

Card Type #44/3
(Chemical Agent Toxicity Data-Probit Slope Definitions)

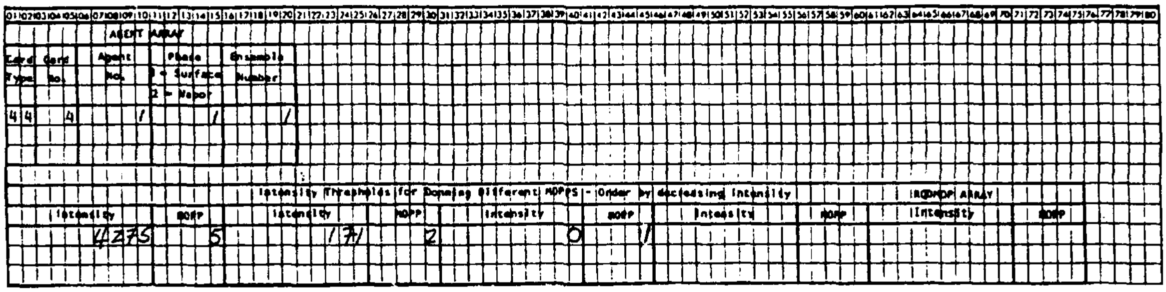
CT44/3 permits the user to define how casualties vary with agent dosage; this is done by defining the dosage for 50 percent casualties and by defining the standard deviation of the log-normal relationship between casualties and dosage. The data entered on the CT44/3 card itself includes only the agent number and the number of the MOPP being worn. Following each CT44/3, three additional special cards are required, each using a format (6F10.0) that permits decimal numbers to be entered. The three cards correspond to (a) the agent in liquid droplet form (i.e., the percutaneous effects of chemical droplets on personnel), (b) the percutaneous effects of vapor, and (c) vapor inhalation. On each of these additional cards the effect-dosage relationship is specified

by entering the dosage for 50 percent response and the standard deviation in the log-normal distribution of that relationship (the reciprocal of the probit slope). These data are to be entered in pairs; the first pair is for lethal dosages, the second pair for incapacitating dosages, and the third pair for ocular disturbances among personnel. Ocular disturbance is not now modelled in TSAR so this data may be omitted. Dosage units are mg/m^2 for liquid effects and $mg\text{-}min/m^3$ for vapor. A CT44/3 should be entered for each agent that is to be simulated and for each type of ensemble that personnel can be expected to wear.

Sample Data

This CT44/2 identifies that the CW Type for TSARINA target types #11, #12, #13, #14, and #15 are 3, 1, 1, 1, and 3, respectively. The CT44/3 precedes the toxicity data for personnel in MOPP #3 that are exposed to agent #1; the three supplementary cards that must follow each CT44/3 are also shown. The data for agent surface deposition are on the first of these three cards and indicate that 10000 mg/m^2 of agent #2 is sufficient to cause 50 percent fatalities and 5000 mg/m^2 is sufficient to cause 50 percent incapacitating casualties; the corresponding standard deviations in the log-normal distributions are 0.2 and 0.2. The data for the vapor effects are to be expressed in $mg\text{-}min/m^2$.

Card Type #44/4



The CT44/4 card is used to specify what parts of the ensemble should be worn at various levels of contamination. The agent, the nature of the contamination (liquid or vapor), and type of ensemble are specified on each CT44/4; each of these cards must be followed by a special card that is used to enter five pairs of numbers (using the format 5(F10.0,I5)). The first in each pair is the contamination level above which a particular MOPP must be worn, and the second number designates that MOPP. These contamination levels must be entered in *descending* order. The MOPP required for personnel at a facility is determined by searching this list of contamination levels (in descending order) for the first level that is less than or equal to the level inside the facility, and marking the corresponding MOPP; the required MOPP is then the larger number of the two MOPPs found by using this search procedure for liquid and vapor. If the contamination level at which the full ensemble (MOPP #5 in our sample data) must be worn is a sufficiently small number, personnel will be required to wear full MOPP whenever there is any contaminant. This would be appropriate, for example, when detection equipment is minimal and the personnel must wear the full ensemble for an extended period because of ignorance about just what chemical conditions prevail.

Sample Data

These cards control which portions of ensemble #1 must be worn when agent #1 is present in liquid form (the 1 in column 15). MOPP #5 must be worn at any time the liquid concentration exceeds 4275 mg/m^2 at the work place; MOPP #2 must be worn when it exceeds 171 mg/m^2 (but is less than 4275); and MOPP #1 when the concentration lies between 0 and 171 mg/m^2.

Card Type #44/5

Card Type	Card No.	Base No.	TBUDDY Min	Dist	MEDIC	Personnel Types to be Selected for Buddy Care								
44	15	1	40	7		1	4	6	7	62	64	65	0	0

CT44/5 provides data for use with the "buddy-care" feature. When this option is activated by initializing DOBUDY on CT3/5, an uninjured person is selected to assist each casualty caused by airbase attacks (each nonfatal casualty is assisted when DOBUDY = 1, and all casualties are assisted when DOBUDY = 2). The person performing buddy care is selected from the same work crew, when available. If no members of the work crew are available, the program logic tries to find unassigned personnel, of the types specified on CT44/5 for each base, that are in the same squadron, or are also working at wing level. If the casualty was off duty, an off-duty person is sought. The specific personnel types that are to be checked to find a person for buddy care should be entered in the nine fields in columns 16–60.

The personnel type—MEDIC—that is entered in the second field (columns 11–15) for at least one base is the personnel type number that must be used in the TSARINA data base to designate a representative set of locations for buddy care personnel at the time of an attack. If another attack occurs while persons are still providing buddy care for a previous attack, all such persons will be assumed to be exposed to the level of risk estimated in TSARINA for the MEDIC type personnel. Only one personnel type will be used as MEDIC at all bases.

Sample Data

Persons providing buddy care to a casualty from air attack at the time of a subsequent attack are to be assumed to not be at risk at Base #2, because no person type-number has been entered for MEDIC. If other members of a casualty's work group are not available to provide buddy care, personnel types #1, #4, #6, #7, #62, #64, and #65 are to be called upon to help. On the average it takes 40 min to help a casualty reach medical assistance.

Card Type #45/1

PERSONNEL EQUIVALENCE DATA - ALTREQ ARRAY -

Card Type		Personnel Type	2nd Squadron	3rd Squadron	Wing Personnel	Personnel Type	2nd Squadron	3rd Squadron	Wing Personnel	Personnel Type	2nd Squadron	3rd Squadron	Wing Personnel
45	1	1	21			2	22		72				

When subsets of personnel or equipment of the same kind are assigned to different on-base organizations, it is necessary to designate each subset by a different number in TSAR, as illustrated in Fig. 15, in Sec. XX. The CT45/1 cards provide TSAR with the necessary data by which personnel of common skills are identified. Identical personnel types may be assigned to up to three flight-line organizations (e.g., AMUs) and to wing organizations (e.g., CRS and EMS). The personnel type numbers that are identified with the on-equipment maintenance task requirements on CT5 and CT6 should be entered under "Personnel Type" on CT45/1. Personnel with these numbers are assigned to the first squadron. The TSAR numbers for the same types of personnel assigned to the second and third squadrons are entered in the next two fields; those assigned at wing level are entered in the fourth field. These numbers, when entered on CT45/1, *must appear in an ascending sequence.*

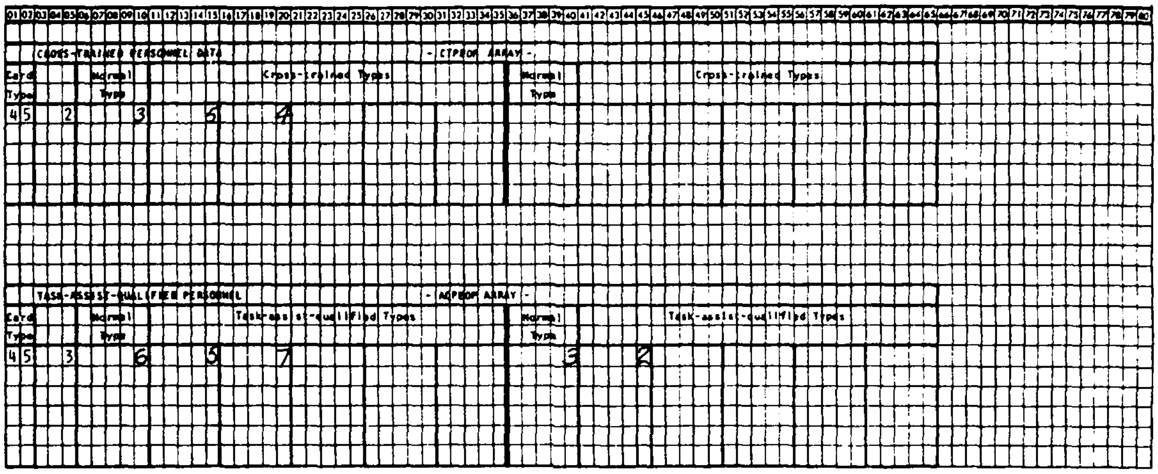
If some personnel types are all assigned to a single pool and used to meet all demands, no entry is required on CT45/1, although the user may wish to enter the personnel type number in the first field as a reminder; the same number will be entered automatically into the other fields. Any personnel type that is identified in the second, third, or fourth fields as an equivalent type should not be entered elsewhere in any field.

These data are used not only to identify within TSAR which personnel types are to be called on when a particular on-equipment task arises in the second or third squadron, they are also used when personnel of a given type are lost or gained; the program automatically adjusts staffs in the several organizations so that their relative sizes are stable.

Sample Data

The entries on the first card indicate that Types #1 and #2 specialists are assigned to squadron #1 and that their counterparts in squadron #2 are Types #21 and #22. There are also some of the second type of specialist assigned at wing level; they are designated Type #72.

Card Types #45/2 and #45/3

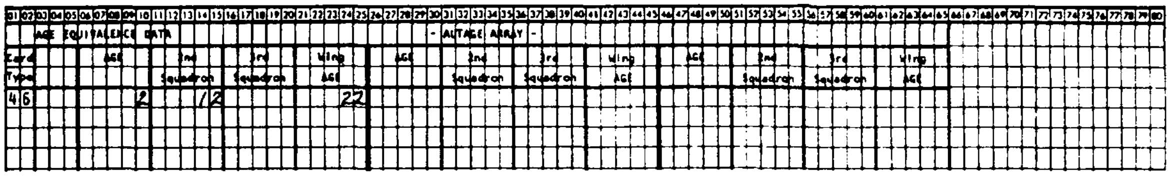


Personnel may be cross-trained to take over certain tasks normally handled by another specialist or to assist another specialist. Other personnel called "task-assist qualified" may be trained only well enough to assist the specialist that regularly handles the job. CT45/2 and CT45/3 permit the user to designate the personnel types that have been trained to replace or assist, or to just assist, other specialists. Up to five personnel types may be specified in each category; when personnel are organized into squadrons, only the designators for those in the first squadron should be entered.

Sample Data

This CT45/2 indicates that Type #5 and Type #4 personnel can replace Type #3 personnel, and the CT45/3 indicates that Types #5 and #7 personnel are trained to assist Type #6 personnel on designated tasks, and Type #2 can assist Type #3 personnel.

Card Type #46



These cards provide the same kinds of information on equipment as are provided for personnel with CT45/1. The rules for choosing numerical designations for AGE are the same as for personnel.

Sample Data

These data indicate that a particular type of AGE is assigned to both of two squadrons, and at wing level. It is designated with Types #2, #12, and #22 at these locations, respectively.

Card Type #47

PARTS REPAIR ADMINISTRATIVE DELAY TIMES

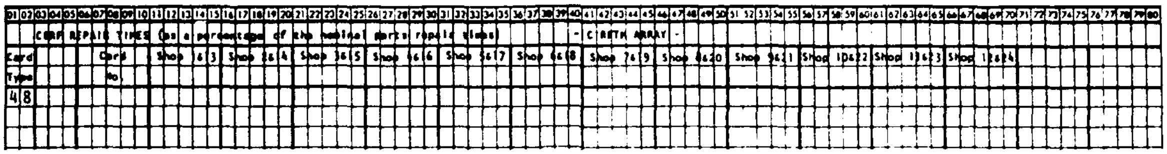
Card Type	Base	Card No.		Shop 1&13 Hrs	Dist	Shop 2&14 Hrs	Dist	Shop 3&15 Hrs	Dist	Shop 4&16 Hrs	Dist	Shop 5&17 Hrs	Dist	Shop 6&18 Hrs	Dist	Shop 7&19 Hrs	Dist	Shop 8&20 Hrs	Dist	Shop 9&21 Hrs	Dist	Shop 10&22 Hrs	Dist	Shop 11&23 Hrs	Dist	Shop 12&24 Hrs	Dist
47			1	12	6	15	6	16	6	12	6	14	6	22	6	8	6	9	6	12	6	16	6				
			2																								
			3	15	6	12	7	8	6	14	6	9	6	19	6	8	6	4	6	19	6	8	6				
			4																								

These cards permit the user to specify the length of the administrative delay for each shop at each base for both parts and equipment repair. These delays should be used to represent the times required to process the necessary paperwork and for intrabase transportation, as well as the delays imposed by the need to await the arrival of necessary component parts that are not tracked in TSAR. When a delay is specified for the shop in which a part or piece of equipment is repaired, repair initiation is deferred until the delay has concluded, unless the control variable EXPED (on CT4/1) has been set to a value greater than unity. In that case, the delay will be reduced to 1/EXPED times the CT47 value when the base has no serviceables. Since a CIRF, if any, is at base #MAXB (a dimension of the user's load module), unique administrative delays may be specified using that base number.

Sample Data

The sample data indicates a mean 12-hour parts repair delay at Shops #1, #4, and #9, and other lengths of time at the other shops; the actual delays are all selected from a Type #6 distribution. For equipment the mean delays range from 4 hours in Shop #18 to 19 hours in Shops #6 and #9.

Card Type #48



Since the environment and procedures at a CIRF could differ substantially from the conditions on an operating base, this card is provided to permit the user to specify a percent by which the times for all the parts repair jobs at a given shop will be modified when they are conducted at a CIRF (the default is 100).

Sample Data

Parts repairs in Shop #1 at a CIRF take half as long as at an operating base.

Card Type #49

EXOGENOUS FACTOR CHANGES - CHANGE ARRAY -

Card Type	Day	Hr	Type	Num	Value	Day	Hr	Type	Num	Value	Day	Hr	Type	Num	Value	Day	Hr	Type	Num	Value	Day	Hr	Type	Num	Value
49	7	23	4	1	28	7	23	4	2	28	7	23	4	3	5										

These cards permit the user to change many of the key control variables or array elements after initiation of the simulation. The mechanism for making these changes is managed in subroutine MODIFY, where the changes are encoded. The changes supported with the current version of TSAR are described in detail in Sec. XIII, Vol. I.

These time-dependent change data are stored in the CHANGE heap and they are introduced exogenously during initialization using CT49. Five changes may be entered with each CT49; data include the day and hour for the change as well as the type of change and the new value. The value of various control variables as well as certain array elements may be changed in this manner.

Provisions also exist for these kinds of changes to be made adaptively during the simulation. For this, the user would need to add code that could decide on a change when some condition was satisfied during the simulation. Subroutine ADAPT, which is called at midnight each day, provides a convenient context within which to introduce such logic, and to schedule the changes that would subsequently be activated with a call to NEWVAL in MODIFY.

Sample Data

The sample entries indicate that (1) the values of the variable PRINT (change Type #4–1) and PPRINT (change Type #4–2) are to be changed to 28 at the end of the seventh day, and (2) the value of CPRINT (change Type #4–3) is to be changed to 5 at the same time.

INPUT-DATA LIST CONTROL CARD

The termination of the basic input data (CT1 through CT49 inclusive) is signalled with a blank CT99. This card is followed immediately by the Input-Data List Control Card. It controls which of the input data is to be reprinted as it is stored in the various storage arrays after program initialization. A 1 in any column between 5 and 42 inclusive (except columns 7, 12, 17, 19, 29, 32, 33, 34, 41) will direct a listing of the data that were entered using the card number corresponding to that column. All temporal data will have been converted to TSAR time units (TTU). In some cases the data will have been rearranged; in others it will have been packed or repacked. The control data entered with CT1 through CT4 are summarized on the first page of the output, regardless of what is on the Input-Data Control Card.

The CT50 cards, which contain the flight demand data, follow this card.

SORTIE DEMAND DATA

Card Type #50

Several different types of sortie demand data are entered with this card type—unique demands, periodic demands, and alert levels, as well as changes in these demand data; several of these are illustrated in Fig. 14. To limit the size of data storage arrays, TSAR permits the sortie demands to be read at user-controlled intervals.

The user may specify flight demands for specific days and at specific times or may specify flight demands that repeat every day ("periodic damands"). Each flight demand may have a probability associated with it, and periodic flight demands may have their desired launch time selected from a (10-hour maximum) time block. Each flight may require up to 32 aircraft; furthermore, up to 31 identical flights may be demanded either at the same time or in a given time block with a single periodic demand entry. The option for periodic flight demands with probabilities provides the analyst a convenient means of specifying a demand pattern that varies randomly from day to day, as might be expected in a wartime environment. The user may also employ any combination of these options. The periodic flight demands must each be numbered by the user in the J-field (i.e., cols. 3–5); the likelihood that each flight is demanded on any given day is entered in cols. 26–30, in percent.

The number of aircraft that are to be placed on alert are also specified with CT50; in this case the Flight Time is interpreted as the time when the alert requirement is to start. These cards are distinguished by a –1 entry for Hours Notice; these demands are not periodic but persist until changed.

Mission priority is denoted with an integer from one to six inclusive; priority number one is the highest priority. Priorities two and four are reserved to denote demands for aircraft that have been placed on alert. Demands for scrambling alert aircraft are presumed to occur without advance notice (i.e., the Hours Notice entry should be zero).

Certain other conditions or constraints are noted in the format illustration. If the minimum flight size and the recovery base are not entered, they are automatically set equal to the maximum flight size and the launching base, respectively. The desired launch time is entered in hours and minutes (e.g., 1545 for 1545 hours).

A group of flight demands may be combined into a single composite flight, in which each flight must satisfy at least the minimum flight size requirement, or the entire

FLIGHT DEMAND DATA - FLTRQT ARRAY -

Card Type	Per. Sched No.	Launch Base	Aircraft Type	Miss'on No.	Priority	Demand Prob	Rqt Flight Size	Dir Flight Size	Hours Notice	Recovery Base	Flight Time Day	Flight Time Hr	Flight Time Min	Periodic Only: No. of Flights	Periodic Only: Block Time (10 Hr Max) Hrs	Periodic Only: Block Time Min
50						(Enter only for periodic flight schedules)	(≤ 16)	(If zero, set to rqt)	Set to zero to scramble alert aircraft. Set to -1 to set/change alert level	(If zero it set to launch base)	Do not enter for periodic flights					
50		2	2	3	1		8	6	6		7	19	15			
50	7	9	1	1	3	75	6	5	10	3		6	30			
50		1	1	2	2		4		-1		4	8	00			
50		1	2	2	1		4	4	8	1	4	12	00			
50		2	1	3	1	200	4	4	8	2	4	12	00			
50		3	2	1	1	200	4	4	8	3	4	12	00			
50																
50		2	2	3	1		-4	3	2		7	17	15			
50																
50	9	1	1	2	2	50	2	2	0	1		9	30			
50	10	2	1	2	3		2	2	2			8	00	4	2	30
50	11	3	2	2	3		2	2	2			8	00	4	2	30
50	12		1	1	1		3	3	8			20	00	4	1	00

Fig. 14—Sortie demand data

composite flight will be canceled. With this feature the user may demand, for example, four CAP aircraft from one base, four defense suppression aircraft from a second base, and four CAS aircraft from a third base. To demand a composite flight, the card images for each subflight must be sequential, and all but the first card image will be identified with 200 for the demand probability. Up to six subflights may be combined into a single composite flight with up to 50 aircraft in total. All elements of a composite flight must be scheduled for the identical launch time. The set of card images defining a composite flight may specify either a unique or a periodic demand. If they specify a periodic demand, the time-block feature and multiple number of flights feature normally available with such types of demand may not be used. The last subflight may be defined as optional, by specifying a minimum subflight size of zero aircraft. This is done by entering a –1 in the minimum flight field to override the default. This may be done only on the last subflight of a composite flight.

A fly-when-ready demand policy may be approximated by using periodic demand cards to specify several flights of, say, 12 aircraft (with as few as one acceptable) every hour and also by permitting aircraft to be launched up to an hour late. Whenever an aircraft completes maintenance during the flying day there will be a demand outstanding that it can fill.

Flight demand data are entered at the time of program initialization and up to once a day thereafter. Those data to be read at program initialization time are terminated with a CT99, that specifies the number of days that should pass before reading subsequent data in columns 3–5. Thus, a 1 in columns 3–5 means that new flight demand data should be read just before the next day starts. If a number greater than one is entered in that field, the periodic flights will be rescheduled for the second day and other days until new flight demand data is read. Flights are scheduled and any new flight data are read each day at 1945 hours.

Another special feature permits a flight to be reduced or canceled before it has been launched, thereby simulating the effects of such changes. This feature is activated when a negative maximum flight size is listed for a flight. Then the entry for the "number of hours notice" is interpreted as the number of hours until the flight that is to be reduced or canceled. Thus, if there is a demand for 12 aircraft at 1545, and a flight of –4 aircraft of the same type and mission from the same base is demanded at 1345 with a two-hour notice, the 1545 flight demand is reduced from 12 to 8 aircraft at 1345, and the minimum permissible size for that flight is the value entered after the value –4.

Whenever new flight data are read in (after as many days have passed as are specified by the preceding data terminator card), both unique and periodic flights may be demanded. As before, periodic flights will be numbered (cols. 3–5), and whenever a number previously used is entered, the new data replace the old. If the new CT50 is blank, except for a previously active periodic flight number, the earlier periodic flight demand is canceled. Each new set of flight data is terminated with a CT99; the number of days before the next entry must be placed in columns 3–5.

TSAR is now dimensioned so that LFQ (currently 1000) flights may be scheduled in any 24-hour period and MAXPER (currently 400) periodic flights may be stored at any one time.

Sample Data

The several card images in Fig. 14 illustrate the various sortie demand options. The first card specifies a demand calling for eight Type #2 aircraft (six minimum) to be launched from Base #2 at 1915 on Day 7; they are to be configured for mission Type #3 and are a top (#1) priority flight. The demand is received at 1315 (i.e., 1915–0600) on Day 7. Since no recovery base is entered, the flight is to be recovered at the launch base.

The second card indicates a flight that is to be launched from Base #3 with a 75 percent probability each day at 0630. Six Type #1 aircraft (five minimum) are to be flown on a Type #1 mission; the demand for this third priority flight is received in the evening at 2030 (10 hours before flight time).

The third card specifies that as of 0800 on the fourth day, four Type #1 aircraft configured for mission #2 will be maintained on alert for mission Type #2 at Base #1. This second priority requirement stands until changed.

The next three cards jointly specify a composite flight to be made up of three sections of four aircraft each from Bases #1, #2, and #3 to be launched at noon of the fourth day. The aircraft types and missions vary from base to base. The demand is received at 0400 on the fourth day and the entire flight must be canceled if all 12 aircraft are not ready; to enhance the likelihood that cancellation will not be required, top priority (#1) is assigned to this composite flight.

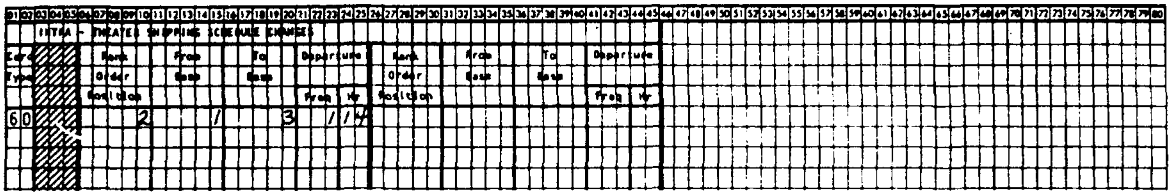
The seventh card exercises the sortie demand revision option. This card specifies that at 1715 on day 7 an order is received to reduce the flight size of a flight two hours later by four aircraft (new minimum is three). Since the flight demand on the first card is for the same base, aircraft type, mission, and priority and is at the correct time, it is reduced to four aircraft (i.e., 8 – 4).

The next card specifies a recurring demand on Base #1: a demand without warning for two Type #1 aircraft, configured for mission Type #2, to be launched immediately at 0930. This demand occurs with 50 percent probability each day. These aircraft will be drawn from the alert force generated by the requirement specified on the third card, if they are available.

The next to last two cards specify recurring demands for four two-aircraft flights from Base #2 and from Base #3; these flights are to be launched each morning at times selected at random between 0800 and 1030. In all cases the demands are received two hours before flight time. At Base #2, Type #1 aircraft are to fly #2 missions; at Base #3, Type #2 aircraft fly #2 missions. A priority of 3 is specified for all of these flights. The flights will not be launched unless both aircraft are ready.

The last card also specifies a recurring demand, but it differs from all other illustrations in that no base is specified. This type of demand is permitted only when the control variables STATE and SELECT have both been initialized to one or greater. When that has been done, TSAR will assign these demands, for four three-aircraft flights between 2000 and 2100, to the bases best able to handle them. The four flights may be assigned to one or more bases, depending upon base capabilities. (All three aircraft in each flight must launch from the same base.)

Card Type #60



Base-to-base shipping schedules may be changed at the same time that changes are made in flight data by entering CT60 cards along with CT50 cards; in fact, only CT60 cards need be entered between CT99 cards. The time for making shipping schedule changes is controlled with CT99 as described for the CT50 cards.

To change any particular schedule, or to add or eliminate a schedule, it is necessary to know the total number of schedules already entered with CT32 and the position of any schedule that is to be changed within that overall number. The order of data entry on CT60 is (1) rank order position of schedule that is changed/added/deleted, (2) new departure point, (3) new destination base, and (4) new departure hour and frequency. If a schedule is to be added, its rank order position must be one greater than the existing number of schedules. Two sets of data may be entered with each CT60.

If the departure frequency is entered as a zero, no further shipments are made on that schedule, unless subsequently revived with another CT60.

Sample Data

These entries indicate that the original shipment schedule from Base #1 to #3 (entered second on the CT32 cards) is to be changed from every other day to daily.

XX. SAMPLE CALCULATION—INPUTS

The entries used in the explanations of the data input procedures in Sec. XIX were largely selected from a complete data base that describes two main operating bases that operate four squadrons of aircraft. Both bases operate two 12-PAA squadrons under the 66–5 maintenance doctrine (i.e., COMO) and each support a DOB. A fifth base is maintained to provide for emergency recovery if the runways at all operating bases have been closed by air attack, and a sixth base in the rear carries out specified aircraft maintenance jobs.

DICTIONARIES

One of the first tasks in developing a TSAR data base is to develop dictionaries of the various categories of resources to be simulated. Figure 15 presents the dictionaries that define the resources considered in the sample calculations to be discussed here. As illustrated for personnel, the dictionaries developed by the user should list both the full real world name (including AFSC for personnel) for each type of resource, along with the number(s) to be used in the TSAR data base to represent that type of resource. As many descriptions of the real world resource types as the user has can usefully be included in the dictionary. For example, in addition to the stock number, it will be helpful if parts are also identified by the appropriate WUC (work unit code).

In addition to airframe-propulsion general (APG) mechanics on the flight-line, each squadron in the sample problem is assigned seven different types of specialists. Similar specialists are also assigned at wing level for intermediate-level maintenance (ILM)—i.e., for repairing aircraft spare parts. Munitions assembly specialists, battle damage repair specialists, and civil engineering personnel are assigned to the wing.

Provisions exist for four types of AGE to be used with aircraft assigned to specific squadrons; all other equipment are available at wing level to fill any on-base demand. The various items in the other resource classes are also specified in the dictionaries.

The identifying number assigned to each resource type is arbitrary. The only restrictions are that the numbers selected must be no larger than the relevant storage arrays, and the designators for civil engineering personnel and equipment should be

larger than (NOPEOP – CEPEO) and (NOAGE – CEAGE), respectively. In the present illustration the PEOPLE array is dimensioned for 200 types of personnel and 20 are reserved for civil engineering types; thus, any designator greater than 180 may be used for civil engineering personnel. When two or more designators are used for the same type of specialist assigned to two or more organizations, the lowest numbered specialist must be in the first squadron, as shown (also see instructions for CT21 and CT45/1).

DATA ORGANIZATION

The simplest and least error-prone method of organizing data for a TSAR simulation is to order the data input card images by their card type numbers. Similarly, the large data collections that define the various tasks are also best organized by ordering them by their task number; thus the on-equipment tasks defined by CT5 would be ordered by the task number appearing in columns 3–7. It is much easier to locate and check data entries when they are organized in this manner. The organization of the input cards was illustrated in Fig. 1.

There are a few *mandatory* rules regarding the order of data entry:

- The first card in the input card-image deck is either blank or has 1 in the columns corresponding to the card types that are to be listed at entry time.
- CT1 through CT4 must be entered in numerical order and before any other cards.

  (Note the special rules regarding columns 3–5 of CT1 and TEST on CT2/1.)

- The CT5 must be entered before the CT7 cards.
- The CT17/3, CT17/4, CT17/5, and CT17/6 cards *must* be entered in order and contiguously for each base, and these data for base N + 1 *must* be entered after base N.
- CT20, CT24, CT25, CT41, and CT42 must be entered in numerical order, and the aircraft references on CT20 and CT41 must be ordered identically.
- When resource data are not entered specifically for each base, but take advantage of the convenience features described for these data (i.e., CT2x/88), the resultant data base depends on card order.

		PERSONNEL					EQUIPMENT		
	AFSC	Sqd #1	Sqd #2	Wing	(Shop)		Sqd #1	Sqd #2	Wing
APG	431×C	1	21		(1)				
Autopilot	325×0	2	22	72	(2)	Power carts	2	12	22
INS	328×4	3	23	73	(3)	Hydraulic mule	5	15	25
Egress	423×2	4	24	74	(4)				3
Pneudraulics	423×4	5	25	75	(7)				4
Structures				76	(7)				6
Navigation	328×0	7	27	77	(9)				7
Radar	328×1	8	28	78	(10)				8
						AIS #1			16
						AIS #2			17
						AIS #3			18
									20
									30
ABDR Specialists				31	(1)				
									28
Munitions									31
Loaders	462LO	6	26		(28)				32
									34
Munitions									
Assemblers	322×2			64	(30)				21
				65	(30)				23
Fueling									
						Tankers	80	81	
						Hot-pits	85	86	
Civil Engineers									
Type A				191	(30)	Dozer			194
Type B				192	(30)	Sweeper			195
Type C				193	(30)	Truck			196
Type D				194	(30)	Scraper			197
Type E				195	(30)	Mixer			198
						Crane			199

AIRCRAFT SPARE PARTS

Simple Parts/LRUs			SRUs			Battle Damage Parts		
1	2	3	101	102	103	201	202	203
4	5	6	107	108	112	204	205	206
7	8	9				211		212
10	11	12						
13	14	15						
16	17	18						
19	20							

MUNITIONS			TRAP		BUILDING MATERIALS	
1	2	3	1	2	1	2
4	5	6	3	4	3	4
11		12	5		5	

COMPONENTS		
51	52	53
54		56

Fig. 15—Resource designator dictionary

- CT44/1, CT44/3, and CT44/4 must each be followed by one or more supplementary data cards.
- The sortie demand data are entered using the CT50 cards after all CT1 through CT49 cards are entered. The CT50 cards are preceded by a "CT99" card and a card that controls input data listings. The CT50 cards are followed by a "CT99" specifying the days before the next additions or modifications to the flight or intratheater transportation schedules. These additions and modifications are contained on additional CT50 following the CT99. The additional CT50 are themselves terminated by another CT99, which indicates when yet another group of CT50 are to be read. This process continues until a CT99 indicates that the next time to read new CT50 is after the end of the simulation. CT60 can appear anywhere with the CT50.

Figures 16 through 26 present the data-entry card-images that comprise the sample problem discussed in this and the following section. As noted above, many of these cards were used in explaining the entries on the various data input formats in Sec. XIX. They are presented here as they would be organized for submission to the computer (including the Job Control Language (JCL) cards that are appropriate on IBM computers). The remainder of this section describes this sample problem and explains what many of the entries on the various card images mean.

CONTROL VARIABLES

CT1 designates, on Fig. 16, three trials of a twelve-day simulation. Six aircraft bases and one aircraft type are to be simulated (NBASE = 6 and NTYPE = 1); crews are to be monitored (CREWS = 1); munitions are to be assembled (BUILD = 1); aircraft are to be sheltered (DOSHEL = 1); and air traffic control constraints are to be observed (DOATC = 1).

Theater resources will be monitored centrally (TSAR = 1) and aircraft parts arriving from CONUS will be managed centrally (CONSIG = 1) using CMODE = 020. The next to last entry on CT1 specifies that the location of the MOS is to be selected on the basis of minimizing the number of craters that have to be repaired, with ties broken in favor of the location with the least total manhours to remove UXO and mines (TSKRWY = 0). The last entry activates the logic that permits time-delayed UXO to detonate at the scheduled time.

CT2/1 calls for limited daily output (PRINT = 2) with cumulative shop statistics to be printed every five days (CUMSTA = 5). A chronological record of on-equipment tasks is to be presented for the aircraft numbered 25 to 36; this record is to be prepared for the first three days of each trial (SCROLL =3). Civil engineering reconstruction is to be accomplished as required (CEWORK = 1), and the resources associated with damaged shops are not to remain at risk to subsequent attacks (ATRISK = 0). Twenty personnel types and twenty equipment types are reserved for assignment to the civil engineers. When an airbase is attacked, TSARINA damage estimates for specific types of equipment are to be applied only to unassigned equipment of those types (ONLYUE = 1); damage to assigned equipment is to be based on the damage estimates for the work location. Aircraft shelters that are damaged are to be repaired as time and resources permit (REPSHL = 1).

The first ten entries on CT2/2 control the several random number streams that may be repeated exactly on each trial. The random numbers that determine sortie selection and uncertain task probabilities will not repeat from trial to trial; those that determine the intratheater transportation departures and arrivals, resource status reports, and zero time shop activity will be the same for all trials.

The other entries on CT2/2 define the policies for managing reparable spare parts. When a base's back shop is damaged and cannot be used for parts repair, a base with an undamaged shop is sought to repair broken parts (SEEKSH = 1). Furthermore, repaired parts are not automatically retained at the base where they are repaired, or sent to the base from which they originated; instead they are shipped to that base defined by the SEND logic in the CONTRL subroutine as having the greatest need for the part (SHPREP = 1). And LRUs that require an SRU that is not normally stocked on an airbase will nevertheless be retained rather than being NRTSed (NRTPOL = 0). Finally, if there is no shipping schedule to the base that has been designated to receive a NRTSed part, the part is NRTSed to CONUS (TODOCK = 0).

The CT2/4 specifies that special reports to summarize aircraft status and describe aircraft tasks will be printed every six days starting at 1900 on day 6. CT2/5 specifies RPRINT = 2 to generate a variety of special reports on runway and taxiway repair work, DPRINT = 1000 to obtain full aircraft status reports, and APRINT = 3 to obtain full reports on the outcome of airbase attacks.

```
/NOOOODEM  JOB  (0000,200,BIN,20),' TSAR DEMO ',CLASS=N
/JOBLIB DD  DSN=N.N0000.A0000.TSAR.MODULE,DISP=SHR
/GO PROC
/GO   EXEC   PGM=TSAR2#89
/GO.FT05F001  DD  DDNAME=SYSIN
/GO.FT06F001  DD  SYSOUT=A
/GO.FT07F001  DD  SYSOUT=B
/GO.FT08F001  DD  DSN=N.N0000.A0000.LONG.RECORDS,DISP=OLD
/GO.FT09F001  DD  DSN=N.N0000.A0000.SHORT.RECORDS,DISP=OLD
/GO.FT10F001  DD  UNIT=TEMP,SPACE=(TRK,(240,16)),
/   DCB=(RECFM=VS,BLKSIZE=10000),DISP=(NEW,PASS)
/GO.FT11F001  DD  UNIT=TEMP,SPACE=(TRK,(2,2)),DISP=(NEW,PASS)
/GO.FT12F001  DD  UNIT=TEMP,SPACE=(TRK,(24,24)),
/   DCB=(RECFM=VS,BLKSIZE=5000),DISP=(NEW,PASS)
/GO.FT15F001  DD  UNIT=TEMP,SPACE=(TRK,(60,8)),
/   DCB=(RECFM=VS,BLKSIZE=10000),DISP=(NEW,PASS)
/GO.FT16F001  DD  DSN=N.N0000.A0000.FORTY.CASE#CW,DISP=OLD
/GO.FT18F001  DD  DSN=N.N0000.A0000.HITS.CASE#CW,DISP=OLD
/ PEND
/STEP1 EXEC GO,REGION.GO=6600K
/GO.SYSIN   DD   *
1111     11111112     2              11         11             INPUT LIST DEMAND
 1 15   12    3    0    7    6    1    1    1    1  020    1    1    1    0    1
   *****************************************************************
   TWO MOBs AND TWO DOBs PLUS EMERG + REAR MAINTENANCE BASES

   FEATURES TESTED INCLUDE:
         "DOB" LOGIC AND THE AIRCRAFT TRANSFER LOGIC
         UXO DETONATIONS;  SUBSEQUENT ATTACKS ON PRIOR "MOS";
         MULTISTEP BACK-SHOP REPAIRS;  AIRCRAFT SHELTER REPAIRS;
         SPECIAL "DOB" BASES, AND "LIMIT-VARIANCE" MOD.
         POSTFLIGHT AND MORNING INSPECTIONS
         NEW MANHOUR SUMMARIES
         MULTIPLE LOCATIONS OF THE SAME TYPE OF PART [ QPA > 1 ]
         ENHANCED RUNWAY AND TAXIWAY RESTORATION PROCEDURES
         CHECK-FLIGHTS AFTER DESIGNATED TASKS
         CE PERSONNEL AND EQUIPMENT LOSSES (AT END OF TASK-SEE CT38)
   *****************************************************************
 2  1    0    0    2  312 25    2    5    0    0 1  0    1  020 20    1    1
 2  2   -1    0    0    0   -1    0    0    0    0    0    0    1    1    0    0
 2  3                        0
 2  4  619  6 0
 2  5    2 1000    0    3    0    0    0    0    0
 3  1    4    1    0    0    2    2   10    5  150    4    0  1 1    0    0    1
 3  2    2    0    2 10 0   40  150    0   10  0 0    5    0    8    0    0    0
 3  3    1    0    8    1    0   12    7   -1   72   22    0    1  240    0   25
 3  4    2    0    1 -500 -200    1    1    2 1  5    3    3    1    1    1    1
 3  5    1 3880   50   15    0    0    0    5    0  118  221  316  424  529
 4  1   12   30   20    7  215  445    0    4    0  480   30   60    0 1500   12
 4  2    0   -1    0    0    0    0    0  200    0   25  0 0  0 0  0 0  0 0    0
 4  3   45    0    0   20
 4  4    0    0    0    0    0    0    0    0    0                             0
```

Fig. 16—JCL for executing TSAR and key control data

CT3/1 indicates that combat operations will be conducted from four bases (OPSBSE=4), and that unscheduled maintenance tasks are to be deferred when they are not essential for the designated mission (POSTPN = 1) but are not to be forgotten (IGNORE = 0). Phased inspection tasks are not to be simulated (DOPHAS = 0). Tasks with criticality greater than 66 may be deferred for two sorties, if not essential for the intended mission (LTHDEF = 2), and parts may be cannibalized from aircraft that already have a part missing, whether or not a reparable of the part type required is on base (CANMOD = 2). Cannibalization may not remove over ten parts from any aircraft (MXHOLE = 10). Parts not normally cannibalized may be cannibalized if five or more aircraft require that part (DOCANN =5 and if CANNTM is not −1); furthermore, LRUs may be cross-canned (CANSRU = 4). If the CT35/1 cards do not specify the task time when a part is obtained by cannibalization, the task time is assumed to equal CDELAY (CT4/1) plus 150 percent of the nominal value (CANMUL = 150). Interrupted and waiting tasks and parts repairs are to be ordered in accordance with TSAR's priority algorithms (ORDIT = 1, ORDWT = 1). Aircraft attrition (but not damage) is to be "regularized" (LMTVAR = 1) to limit the sortie variance across trials.

CT3/2 designates many of the policies that are to be used to manage the transfer of aircraft. Whenever an aircraft is transferred to accomplish maintenance that is mandatory at a rear base, all other required tasks, as well as all deferred tasks that are required for any mission, are also scheduled for completion at the rear base (JOBCON = 2). Whenever aircraft at a combat base are lost, or are transferred to the rear for repair, a filler aircraft, if available, will be sent forward as a replacement (FILLAC = 3), except that the number of aircraft at the combat base shall not exceed the base's shelter capacity (FLEVEL = 2). In addition to the aircraft that are transferred to accomplish tasks that are mandatory in the rear, any aircraft will be transferred to the rear if (1) its required maintenance is estimated to take in excess of 10 hours (MNTLMT = 10), (2) and, if more than 40 [MNTF] percent of the estimated rear-base maintenance time will be required at the forward base to ready the aircraft to be ferried to the rear, then (3) the work in the rear will have to require at least 15 hours (150 [MNTR] percent of MNTLMT). Filler aircraft are launched as replacements at the same time that aircraft are launched on ferry flights to the rear (QUIK = 0). To provide aircraft spare parts for the tasks that will be done in the rear as a result of the policy of transferring aircraft requiring more than 10 hours maintenance, 10 percent of all aircraft spares will be stocked (RPARTS = 10) at

the sixth base (identified on CT15/2 as the rear maintenance base). Base #5 will be used to recover aircraft that cannot land at combat bases because all runways are closed (EMERG = 5). Preflight tasks are not to be restricted during refueling (NOFUEL = 0).

The UNCER entry on CT3/2 specifies that the unscheduled maintenance task probabilities that occur in wartime—i.e. during the simulation—are to be different from the values that are derived from peacetime data (which are entered with CT7). The new values are to be determined using distribution #8 in the TTIME subroutine (UNCER = 8) (i.e., a normal distribution with a standard deviation equal to one-eighth the mean); the breakrate entered with CT7 is to be treated as the mean of the distribution, with the wartime value of the breakrate determined by a random selection from that distribution. A different set of breakrates will be selected for each trial, rather than being held constant across trials (col. 30 on CT2/2). These breakrates will be assumed to be invariant with the achieved sortie rate (VBREAK = 0).

CT3/3 designates that parts are to be initialized at bases designated with CT23/70 cards (OUTFIT = 1); since WRSK kits will not be stocked at MOBs or DOBs, TSAR's approximation to the Air Force DO-29 cost-optimization procedures is not relevant (PMODE = 0).

Parts shortages other than those in the pipelines are to be simulated; stock levels are to be under the prescribed levels by 12 percent across the board (SHORT = 12). In addition, certain parts suffer an additional shortage of 6 to 28 percent (i.e., 72 to 72 + 28 percent of the nominal levels); the likelihood of a part suffering this additional shortage will be proportional to part cost (TOOFEW = –1). Parts are to be initialized in depot pipelines at nominal levels (FULL = 0) and their selection is to be governed by the binomial approximation (RANDM = 1). If there are insufficient spares procured to fill the pipeline, they will not be obtained by creating holes in aircraft (ZNORS = 0). All pipeline deliveries are to be delayed by seven days (HIATUS = 7). The parts initialization process, including the randomly chosen shortages, are to be repeated for each trial (NEWPRT = 1) rather than using the same sets of assumptions for each trial (NEWPRT = 0). To limit unnecessary processing, the highest numbered part is declared (NPART = 240). When an aircraft is damaged by an attack, 25 percent of the parts are salvaged (FSALVG = 25).

CT3/4 specifies that the degradations imposed under CW conditions will be considered (USECW > 0) and that CW attacks will be simulated (USECW = 2). Only

one agent will be used in the CW attacks (NAGENT = 1). Personnel will not be warned of the first chemical attack until five minutes after the chemical weapons are burst; for subsequent attacks they receive notice of the attack two minutes after the burst time. The MOPP numbers that define what portion of ensemble #1 is being worn range from #1 to #5. When warned of a CW attack all personnel get into their full ensemble—MOPP #5—until the chemical contamination at their work place falls to the safe level for a lower MOPP (VARMOP = 1). Subsequent to chemical attacks the estimates of liquid and vapor contamination at each monitoring point will be updated every two hours (CWFREQ = 2). With CPRINT = 1, dosage data and current MOPP requirements will not be listed. Before chemical attacks, maintenance personnel on the flight-line are to wear MOPP #3; all others remain in MOPP #1 until an attack occurs.

CT3/5 is used to specify other conditions that affect the simulation of the chemical environment. Since RECUP is set to 1, personnel who collapse from heat exhaustion or are hospitalized for other reasons will be returned to work when their hospitalization is completed. Personnel will be allowed to work on a task until their rectal temperature reaches 38.80°C, or until they are limited by one of the Vogt constraints (NOVOGT = 0). They are then required to rest until their temperature falls to within one-half degree Centigrade (DELTA = 50) of their equilibrium temperature at their rest place and until their rest time satisfies the Vogt conditions. It will be assumed that personnel have not been regularly wearing their chemical ensembles immediately before the simulation begins (i.e., NACC = 0 days acclimatization), and that 0.5 percent of the personnel have masks with a bad fit (CWRISK = 5). If personnel casualties are sustained during an attack, no personnel will be used to provide "buddy care" (DOBUDY = 0). When runway repair personnel are released from the "cooler," and there are insufficient persons available to initiate the basic runway repair procedure, the assignment of the released personnel is delayed up to 15 minutes if more runway repair personnel will be released within that time (HOLDUP = 15). The default values of the five heat factors entered for the generic tasks are slightly different from the values provided in the program (see subroutine INPUT).

CT4/1 specifies that aircrews must have a minimum of 12 hours off each day and that they must be on the ground for at least 30 minutes between flights. The administrative delays for parts and equipment repairs are reduced to one-seventh of their CT47 values, if no serviceables are available when a reparable part is removed from an

aircraft, or if no other serviceable piece of equipment is on base (EXPED = 7). The flying day is expected to be largely complete by 8:00 PM (ENDAY = 20) and deferred maintenance may be initiated after that hour for aircraft that do not have a flying assignment. Such maintenance will be initiated if the estimated maintenance completion time is no later than 0445 (LSTTOD = 445), at which time munitions loadings that have been delayed should be initiated; otherwise delayed loadings should start at 0215 (LOADTM = 215). No parts may be cannibalized from any aircraft that has an estimated ready-to-fly time within four hours (DOWNTM = 4).

Eight hours are required to package all resources that are to be shipped to another base within the theater (PKGTM = 480 min). After an air attack, civil engineers will be engaged for 30 minutes to take care of the disruptive effects of fires, broken fuel and water lines, clogged roads, etc., before they can begin reconstruction (CEDELY = 30), and all unscheduled maintenance, back-shop work, and munitions assembly jobs will be similarly delayed for 60 minutes (SHPDLY = 60). Other delays may be imposed in addition to these; see CT17/9.

CT4/2 indicates that daily projections of each base's sortie generation capability will not be prepared (STATE = 0) and sortie demands will not be reassigned when a base's runways are closed (SELECT = –1). Parts that have a probability greater than 20 percent of being broken when being cannibalized will not be cannibalized (DOCANN = 200), and 25 percent of the casualties inflicted by conventional weapons are fatal. The planning time horizon, as a function of the time of day, is to be that provided by TSAR's default conditions (see Sec. IV.16, Vol. I). On CT4/3, TBEFOR specifies that aircraft recovering at a DOB within 45 minutes of ENDAY that require deferred maintenance, should recover at their host base, and CEOVER permits civil engineers to work up to 20 minutes overtime to complete an ongoing task.

TASK DESCRIPTIONS

The most difficult data preparation activity for TSAR is development of data defining what jobs need to be done, how often, with what resources, and taking how long. CT5, CT6, CT8, CT9, CT10, CT11, CT12, CT13, CT14, and CT38 are used to enter these data for unscheduled aircraft maintenance, parts repair, equipment repairs, munitions assembly, aircraft loading and reconfiguration, and for civil engineering base recovery tasks.

Figure 17 illustrates 55 on-equipment aircraft maintenance tasks (CT5); 28 are unscheduled tasks, 7 deal with refueling, basic munitions, decontamination and morning inspections, and 10 relate to battle damage. Tasks #2, #7, #13, #15, #18, and #32 constitute task networks. Tasks #6 and #11, as well as battle damage tasks #103 and #107, require that the appropriate shop facility be available; furthermore, if the first two tasks arise for aircraft at a DOB, the work must be carried out at a rear maintenance base. The latter is true for Tasks #2, #10, and #13 as well. When Tasks #1, #7, #12, #15, #17, or #18 occur for aircraft on a DOB, the aircraft must return to its host base. Alternative task procedures are defined (CT6) for Tasks #3, #7, and #13.

The probability that the unscheduled tasks are needed after each sortie are specified on the CT7 cards; Tasks #1, #2, #6, #7, and #10 occur after 2.45, 5.00, 8.34, 4.60, and 3.92 percent of the sorties, respectively. These cards also specify the probability that the aircrew is unable to detect the need for these tasks before recovering at a DOB; these tasks will go undetected one-half the time (except for Tasks #31, #32, and #35).

Parts repair procedures (CT8) are included for eight LRUs and 2 SRUs in Fig. 18. Two parts (#2 and #8) involve SRUs. Part #5 has four possible repair procedures, one of which is chosen randomly when the part breaks. The repair procedure for part #1 has three steps, #1, #21, and #22; the likelihood that steps #21 and #22 are required is 75 and (given that step #21 was required) 60 percent, respectively. The repair of part #2 requires one of three possible SRU replacement procedures (#101, #102, or #103), or procedure #601 that does not require an SRU. Some of these procedures are multistep, and SRUs #101 and #102 may themselves be repaired. Alternate repair procedures are defined (CT9) for parts #1, #4, and #7, and for the repair procedures for part #1 that use SRUs #101 or #102.

Equipment repair procedures are provided for nine types of equipment: Types #2 to #8, and #21 and #23. The necessary procedure for equipment #2 is selected at random from procedures #51, #52, and #53. Repair procedures #51 and #53 involve multiple steps, and the last step (#67) of the #53 path has an alternate specified (#68). Repair of equipment #3 involves a two-step procedure (#3 and #46) and repair of #5 involves a three-step procedure (#5, #41, and #42). Repair procedures are not given for equipments #16, #17, and #18; instead they are identified (by the negative numbers) as AIS stations Type #1, #2, and #3, and handled according to the procedures described in connection with CT22/66 and CT22/77.

```
             5    11 2    0  102  201    0  2  0   0   00-10  0   0    0    0    0    0   00
             5    22 2    1  250  201  302  2  3   0   00  7  0   4    0    0    0    3 3140
             5    32 2    0  150  302    0  0  0   0-4000  0  0   0    1    4    0    0   00
             5    42 2    0  400  102    0  2  0   0-3500  0  0   0    0    5    0    0   00
             5    52 2    0  300  201    0  0  0   0-2500  0  0   0    0    0    0    0   00
             5    65 3    2  200  303    0  3  2   0   00-20 60   1    0    0    0    0 2250
             5    71 3    3  150  302    0  2  3   0   00-10 50   0    2    0    0    8   01
             5    81 3   -1  400  301    0  0  0   0 4000  0  0   0    0    0    0    9   00
             5    91 3    0  100  302    0  3  2   0 3000  0  0   0    0    0    0    0   01
             5   102 5    4  250  402    0  0  0   0   00-20 80   0    0    0    0    0   00
             5   115 5    0  180  401  502  4  0   0   00-10  0   0    0    0    0    0 4190
             5   121 5    5   80  401    0  4  2   0   00-20 40   0    0    0    0    0   00
             5   132 7    0  320  502    0  5  0   0   00-10  0   0    3    0    0   14   00
             5   142 7    6  120  502    0  0  0   0 5000  0100   0    0    0    0    0   00
             5   151 9    0  280  701    0  6  2   0   00-20  0   0    0    0    0   16   00
             5   161 9    7  160  702    0  6  3   0 2500  0100   0    0    0    0    0   00
             5   17110    8  220  802    0  7  0   0   00-10 75   0    0    0    0    0   00
             5   18110    9  140  801    0  0  0   0   00-20 45   0    0    0    0   19   00
             5   19110    0  150  802    0  0  0   0-3300  0  0   0    0   23   21   20   00
             5   20110   10  250  801    0  0  0   010000  0 77   0    0    0    0   21   00
             5   21110    0  160  801  701  0  0   0 7000  0  0   0    0    0    0   22   00
             5   22110   15  240  802    0  0  0   0 8000  0 75   0    0    0    0    0   00
             5   23110   12  190  801    0  7  0   0-1500  0100   0    0   24   21   21   00
             5   24110   14  320  802    0  0  0   0 6000  0 60   0    0   25   21   21   00
             5   25110   -1  120  801    0  7  0   0-5200  0  0   0    0    0    0   26   00
             5   26110   11  320  801    0  0  0   0 8000  0100   0    0    0    0   27   00
             5   27110    0  140  802    0  6  7   0-6000  0  0   0    0   28    0    0   00
             5   28110   13  240  701    0  0  0   0-4000  0100   0    0    0    0    0   00
             5   31 12   16   10  401    0  4  2   0   00 32100   0    0    0    0    0   00
             5   32 12   17   12  402    0  5  0   0   00 32  0   0    0    0    0   33   00
             5   33 12   18   10  4 1    0  0  0   0-5000  0100   0    0   34    0    0   00
             5   34 12   19   15  2 1    0  2  0   0-5000 32  0   0    0    0    0   35   00
             5   35 12   20   20  4 1    0  3  0   0    0  0100   0    0    0    0    0   00
             5   41 29    0  100  102    0 80  0  10   01 33  0   0    0    0    0    0   00
REFUELING
             5   42 2520405  150  602    0  0  0  15 6001  0  0   0    0    0    0    0   01
AUX TANKS
             5   43 2510812   80  602    0 31  0   810001  0  0   0    0    0    0    0   02
A-A MISS
             5   44 2510411   50  602    0  0  0   510001  0  0   0    0    0    0    0   01
GUN
             5   51  1    0   50  102 ... 0 85  0   510000  0  0   0    0    0    0    0   00
HOT-PIT
             5   52  1    0  150  102    0  0  0  1510000  0  0   0    0    0    0    0   00
DECON
             5   53  1    0   60  102    0  5  0   0   01  0  0   0    0    0    0    0   00
AM INSPEC
             5   61  1    0  100  201    0  0  0   0  150  0  0   0    0    0    0    0   00
             5   62  1    0   50  201    0  0  0   0  200  0  0   0    0    0    0    0   00
             5  101  1  20110001 3201    0  0 01000  600 33100   0    0    0    0    0   00
ABDR
             5  1021 1  202 6001 3102    0  0  0 600 1400 32100   0    0    0    0    0   00
             5  1034 1  203 1601 3101    0  0  0 160 2940 32100   0    0    0    0    0   00
             5  104  1  204 1001 3202    0  0  0 534 3470 33100   0    0    0    0  111   00
             5  1051 1    0  201 3101    0  0  0  2010000 32  0   0    0    0    0    0   00
             5  106  1  20516001 3202    0  0 01600 1530 33100   0    0    0    0    0   00
ABA-ABDR
             5  1074 1  206 7501 3101    0  0  0 750 3870 37100   0    0    0    0    0   00
             5  1082 1    0  501 3102    0  0  0  5010000 32  0   0    0    0    0    0   00
             5  111  1  211  501 3101    0  0  0    0 8000  0  0   0    0    0    0  112   00
             5  112  1  212 2000 3101    0  0  0   010000  0  0   0    0    0    0    0   00
             5  201 25    0  100  101  201  5  0   0   01  0  0   0    0    0    0    0   00
             5  202 25    0   80  201  102  3  0   0   01  0  0   0    0    0    0    0   00
             5  203 25    0  100  102    0  7  0   0   01  0  0   0    0    0    0    0   00
             6  0    1  250  202  101  0  0    0    0    2   350   302 1200  4  0    4    0    0
             6  0    3  480  601  701  0  0    5    0    4   500   3 1  101  2  3    0    0    0
             6  0    5  700  301  0 0  3  0    0  0 0
             7  1    1  245   50    2  500   50    6  834    50     7  460   50   10  392   50
             7  1   11  385   50   12  280   50   13  873    50    15  270   50   17  940   50
             7  1   18  553   50   31  345   25   32  543    40    35  626   60
```

Fig. 17—On-equipment tasks, task alternates, and probabilities

8	1	1	2	660	7201	22	0	1	335	0	21	0				
8	2	2	3		-1	101										
8	1	3	3	460	7302	3	0	0	0	0	0	0				
8	1	4	5	840	7402	4	0	2	318	0	0	0				
8	2	5	5		-2	104										
8	2	8	10		-1	107										
8	1	6	7	400	7602	25	0	0	332	0	0	0				
8	1	7	9	380	7702	16	0	3	0	0	0	0				
8	3	101	102	680	7301	3	0	131	50	0	1	3	151			
8	3	102	103	960	7301		0	134	30	0	1	4	171			
8	3	103	601	440	7301	3	0	0	10	0	0	0	0			
8	3	104	105	600	7401	4	0	0	25			0				
8	3	105	106	760	7402	4	0	0	10		1	0				
8	3	106	603	880	7402		0	0	40			0				
8	3	107	108	620	7702	18	31	0	33			0				
8	3	108	0	1080	7701	18	0	0	67			0				
8	3	601	0	600	7301		0	-1	10			0				
8	3	603	0	450	7401		0	-1	25			0				
8	3	131	132	480	7701	16	0	0	0			0				
8	3	132	133	600	7701	16	0	0	20			0				
8	3	133	0	200	7701	16	0	0	80	0	0	0	161			
8	3	134	135	160	7801	17	0	0	33	0	0	0	181			
8	3	135	0	170	7801	17	0	0	67			0				
8	4	21	80	200	73 1	22	0		75	0 0	0	0	22			
8	4	22	40	150	72 1	0	0		60	0 0	0	0	0			
8	4	151	40	300	74 1	0	0		80	0 0	0	0	152			
8	4	152	80	200	73 1	0	0		50	0 0	0	0	0			
8	4	161	60	200	78 1	0	0		78	0 0	0	0	162			
8	4	162	40	300	77 1	0	0		88	0 0	0	0	0			
8	4	171	50	150	74 1	0	0		66	0 0	0	0	172			
8	4	172	80	300	77 1	0	0		55	0 0	0	0	0			
8	4	181	40	200	77 1	0	0		88	0 0	0	0	182			
8	4	182	60	250	78 1	0	0		77	2123	1	0	0			
9	0	1	1050	7301	0	0	0	0	2	1260	7401	4	0	0	0	0
9	0	3	920	7701	11	0	0	0	4	1120	7201	0	0	0	0	0
9	0	5	150	7801	31				6	140	7801	32				
9	0	7	40	7801	32				8	20	7702	31				
10	0	2	2	626	0	-1	51	0	0	0	0	0	0	0	0	0
10	0	3	3	278	500	7302	0	0	0	0	0	46	0	0	0	0
10	0	51	52	400	400	7201	0	0	0	332	0	61	0	0	0	0
10	0	52	53	100	800	7201	20	21	0	228	0	0	0	0	0	C
10	0	53	0	500	1200	0	21	20	0	334	0	66	0	0	0	0
10	0	4	5	519	800	7501	0	0	0	0	1	0	0	0	0	0
10	0	5	7	48	750	7501	0	0	0	0	1	41	0	0	0	0
10	0	6	9	96	400	7701	0	0	0	0	1	0	0	0	0	0
10	0	7	10	339	1100	7801	0	0	0	0	0	0	0	0	0	0
10	0	8	1	215	1200	6301	0	0	0	427	0	0	0	0	0	0
10	0	16	10	0	-1	0	0	0	0	0	0	0	0	0	0	0
10	0	17	10	0	-2	0	0	0	0	0	0	0	0	0	0	0
10	0	18	10	0	-3	0	0	0	0	0	0	0	0	0	0	0
10	0	21	1	62	800	6302	0	0	0	0	0	0	0	0	0	0
10	0	23	1	115	2000	6302	0	0	0	0	0	0	0	0	0	0
10	0	41	0	600	50	7302	0	0	0	0	0	42	0	0	0	0
10	0	42	0	300	30	7202	0	0	0	0	0	0	0	0	0	0
10	0	46	0	800	50	7201	0	0	0	0	0	0	0	0	0	0
10	0	61	0	800	60	7202	0	0	0	0	0	62	0	0	0	0
10	0	62	0	400	20	7201	0	0	0	0	0	0	0	0	0	0
10	0	66	0	750	20	7301	0	0	0	0	0	67	0	0	0	0
10	0	67	0	500	40	7201	0	0	68	0	0	0	0	0	0	0
10	0	68	0	0	60	7301	0	0	0	0	0	0	0	0	0	0
11	1	-1	400	6503	210	0	61	338	2	1200	6404	230	0	0	0	0
11	1	-3	700	6503	210	2300	0	0	4	300	6403	210	0	42	0	0
11	1	5	1050	6404	230		021000	432	-6	950	6502	230	0	2	0	0
11	1	11	1400	6404	0	0	0	0	12	450	6402	0	0	0	0	0
11	1	21	1400	6404	0	0	0	0	0	0	0	0	0	0	0	0
11	2	1	521	531	561											
11	2	12	511	521	532	541										

Fig. 18—Parts and equipment repairs and munitions assembly tasks

Munitions assembly procedures (CT11/1) are listed for the eight types of munitions; alternative procedure #21 is specified for assembly of munition Type #5. Three of the munitions (#1, #3, and #6) are unguided, and three assembly procedures (#1, #4, and #6) can take advantage of cross-trained or task-assist-qualified personnel. Munitions #1 and #12 are composed of several components that are listed on CT11/2.

MISSION AND MUNITIONS DATA

The standard combat loads for the three missions to which aircraft Type #1 can be assigned are specified with CT12 in Fig. 19. SCL #1 is the preferred load for mission #1, and SCL #2 is an alternative; the effectiveness indexes for sorties that are launched with these combat loads are 110 and 90, respectively. Resource requirements for uploading the various combat loads and for configuring aircraft for those combat loads are specified with CT13 and CT14.

The various data that define operational factors for aircraft Type #1, and for that aircraft's three missions, are entered on the several CT15 cards, and on CT15/88, and CT16. The CT15/1 data specify five units of fuel, fueling Task #41, a nominal time for a complete sortie and maintenance cycle of 2 hours and 30 minutes, a munitions load team of two Type #6 personnel, and basic munitions Types #11 and #12. Data are also given that define the battle damage tasks, Base #6 as the location for rearward maintenance, the hot-pit fueling task (#51), aircraft decontamination task (#52), early morning inspection task (#53), and postflight inspection Tasks #201 and #203 following missions #1 and #3. CT15/88 specifies that check flights may be required following Tasks #6, #12, and #15 and ABDR Tasks #101 and #104, and the probabilities that they are *not* required The CT16 cards define the characteristics of missions #1, #2, and #3, and specify the associated attrition rates over the first 60 days.

Extensive data describing the characteristics of the first and third airbases are shown in Fig. 19 with 11 kinds of CT17 cards; comparable data are included in the complete data base for Bases #2, #4, #5, and #6. Bases #1 and #2 are defined as MOBs (col. 15 on CT17/1) and Bases #3 and #4 as DOBs; Base #1 is defined as the host for Base #3 and Base #2 as the host for Base #4 (col. 13 on CT17/1). Note that relatively limited data are required for Bases #3 through #6 since they are not to be subjected to air attack in this sample problem. The shift schedules and task incompatibility data are entered on the CT18 and CT19 cards shown on Fig. 20. Most shops change shift at 0800;

```
12       1    1    1    1  110    2   90
12       1    2    1    3  100    4   60
12       1    3    1    5  190
13  1   10 1203  112   31   32  602  223  700  502   32    0  602  327    0    0
13  2   20  800 1202   31   34  602    0    0    0    0    0    0    0    0    0
13  3   30  700  304   32   31  602    0    0    0    0    0    0    0    0    0
13  4   40 1000  106   31    0  602  325  600  402   32    0  602    0    0    0
13  5   50 1800  604    0    0  602    0  400  302   32    0  602    0    0    0
14  1 1001   21   34   32  602  360  801   41   28    8  602  231    0    0    0
14  2  500   12   34   31  602  345    0    0    0    0    0    0    0    0    0
14  3  300   12    0    0  602    0  200   31    0    0  602    0    0    0    0
14  4  800   42    0    0  602  442    0    0    0    0    0    0    0    0    0
14  5  400   31    0    0  602    0    0    0    0    0    0    0    0    0    0
15  1    1    6         5   41    3   60  150    1  6 2    2    4 11 1 12 2
15  2    1   60  101  105   40  106  108  100  202  100    6    0    0    0    0
15  3    1    2   51   52    0    0    0  103  106    0    0
15  5    1   53  201    0  203    0    0    1
15 88    1    6    0   12 2500   15 1000  101 5000  104    0
16  1 1 30  600 30    8   35   15    1   80   25   25 1 65 3 48 5 42 9 3260 25
16  1 2  0  600 30   10   20    6    1   30   25   25 2 58 4 43 7 3612 2860 18    1
16  1 3 24  750 15    5   40   12    1   60   25   25 3 48 6 3911 2816  960  7    1
17  1    1    1         1         4   24   10     428000 80 4   60   12    0    1
17  2 1100   80  100  100  100    0    0    0    0    0    0    0    0    0    0
17  3    1   42   45    2    2  125    0    0    0  430    1        20   43    0
17  4    1    1    1    2   10    2    2    3   10    3    3    4   10
17  4    1    4    4    5   10    5    5    6   10    6    6    7   10
17  4    1    7    8    9    4    8    9   10    5    9   10   11    3
17  4    1   10   11   12    8   11   12   13   10   12   13   14   10
17  4    1   13   14   15    8   14   15   16    3   15   16   17    6
17  4    1   16   17   18    3   17    1    8    9   18    4   13    9
17  4    1   19    7   18    9   20    8   19    3   21   19   20    2
17  4    1   22   19   21    4   23   21   22    4   24   22   23    2
17  4    1   25   22   24    4   26   24   25    2   27   24   26    4
17  4    1   28   26   27    4   29   27   28    2   30   11   27    3
17  4    1   31   10   29    2   32    9   30    2   33   15   32    3
17  4    1   34   31   32    2   35   31   33    4   36   33   34    4
17  4    1   37   34   35    2   38   34   36    4   39   36   37    2
17  4    1   40   36   38    4   41   38   39    4   42   39   40    2
17  4    1   43   18   40    3   44   17   41    2   45   16   42    2
17  5    1    1   20   20   23   23   25   25   28   28   29   29
17  5    1   11   30   30   32   32   35   35   37   37   40   40
17  5    1   21   41   41   42   42
17  6    1    1    1    2    3    4    5    6
17  6    1    2    7    8    9   10   11   12   13   14   15   16
17  7    1    0 3000   75    2 2500   50   -1    6
17  8    1    1    1   60   40
17  8    1    2    1   13   14
17  9    1   10   60  120   20    0    0    0    1
17 10    1     0    0   60    0    0    0
17 11    1    1   10   60   90   20   60   90
17 11    1    2   10  -50  -50   20  -50  -50
17 11    1    3  -20  -20  -20  -20  -20  -20
17 11    1    4  -30  -40  -40  -30  -40  -40
17 11    1    6   10   20   20   10   20   20
C  BASE 3 USES A 66-1 ORGANIZATION: BACK-SHOP SPECIALISTS ARE NOT REQUIRED
17  1    3  1 3    1    0    0    0    0    0     020000 80 4   60   12    0    1
17  2 3100  100  100  100  100    0    0    0    0    0    0    0    0    0    0
17  3    3    0    0    1                        0  415    1
17 11    3    1   10   60   90   20   60   90
17 11    3    2   10  -50  -50   20  -50  -50
17 11    3    3  -20  -20  -20  -20  -20  -20
17 11    3    4  -30  -40  -40  -30  -40  -40
```

Fig. 19—Combat loads, aircraft and mission data, and data for Base #1

only the munitions specialists and other personnel in Shops #25, #27, #28, #29, and #30 change shifts earlier in the day in order to ready aircraft for flight.

BASE RESOURCES

The resources available at each base at the beginning of the simulation are defined with CT20 through CT27. When the resources on two or more bases are the same, in part or in total, the features described in Sec. XIX can be used to reduce the required number of card images.

```
18  1    1 8 30 8     8     8 20 8     8     8 20 8     8     8
18  1    2 8    8     8     8    8     8     8    8     8     8
18  1    3 8    8     8     8    6           4    4     6 60 2
18  2    1    1  100   120    80   100   100   100    80   100   100   100
18  2    1    2  100   100   100   100   100   100   100   100   100   100
18  2    1    3  100   100   100   100   100
19  1   10   12    0    14     0
20  1   12   24   48
20  2   12   24   48
20  3    1    0    0
20  4    1    0    0
20 66  1 3  1 3 1  4    1  318  3 1 1  4    0
20 66  1 5  2 4 1  4    1  415  4 2 1  4    0
20 66  6 5  1 3 1  6    1  918  3 1 1  6    0
20 66  5 3  2 4 1  5    1  9 4  4 2 1  5    0
20 77    1   18  180
20 99    1   24

21  1    1  48  48 30  30  102    2  16  16  8   8  202    3  10  10  6   6  303
21  1    4  12  12  8   8  502    5   8   8  4   4  702    6  32  32 20  20 2802
21  1    7   8   8  4   4  902    8   8   8  4   4 1002    0   0   0  0   0    0
21  1   21  48  48 30  30  102   22  16  16  8   8  202   23  10  10  6   6  303
21  1   24  12  12  8   8  502   25   8   8  4   4  702   26  32  32 20  20 2802
21  1   27   8   8  4   4  902   28   8   8  4   4 1002    0   0   0  0   0    0
21  1   31  20  20 10  10  102   32  10  10  4   4  102   63  20  20 10  10  102
21  1   64  80  80 54  54 3004   65  88  88 56  56 3003    0   0   0  0   0    0
21  1   72  10  10  6   6  202   73   4   4  4   4  302   74   4   4  2   2  502
21  1   75   4   4  2   2  702   76   5   5  3   3  702   77   5   5  3   3  902
21  1   78   8   8  4   4 1002    0   0   0  0   0    0    0   0   0  0   0    0
21  1  191  90  90 45  45 3010  192  96  96 48  48 3006  193  16  16  8   8 3002
21  1  194  40  40 20  20 3008  196   6   6  3   3 3002    0   0   0  0   0    0
21 88    1    2

22  1    2  4 4    2    3  3 3    3     4  5 5    5     5  5 5    7     6  2 2    9
22  1    7  2 2   10    8  2 2   27    12  4 4    2    15  5 5    7
22  1   16  1 1   10   17  2 2   10    18  2 2   10
22  1   20  4 4    1   21 1818   30    22  4 4    2    23 1010   30    25  1 1    7
22  1   28  2 2   27   30  5 5   10    31  8 8   28    32  6 6   28    34  3 3   27
22  1   80  4 4   29   81  4 4   29    85  1 1   29    86  1 1   29
22  1  194 1212   30  195  3 3   30   196  3 3   30   197  7 7   30
22  1  198  7 7   30  199  3 3   30
22 88    1    2
22 66    1    1  200   62    25   15    16
22 66    2    5  249   62    26   21    17
22 66    3    9  131   62    33   26    18
22 77    1 1200  700  560   140  973 1680 1320  912   415 1265
```

Fig. 20—Shift times and break-rate data; aircraft and transfer directives, personnel and equipment resource data

The initial numbers of aircraft and pilots allocated to each base are specified with CT20 shown in Fig. 20. Their initial mission configuration will be specified later with the CT41 cards on Fig. 24. Each of Bases #1 and #2 (the MOBs) has 24 Type #1 aircraft, organized into two squadrons, and 48 aircrews. There are an additional 18 aircraft available as fillers, and another 24 are in CONUS.

The aircraft transfer directives are defined with the CT20/66 cards. On the morning of day 1, each MOB is to transfer four aircraft configured for mission #1 to its DOB: host Base #1 to Base #3 at 0300 and host Base #2 to Base #4 at 0500. Four aircraft are to be maintained at each DOB until the afternoon of day 3 on Base #3 and day 4 at Base #4. Subsequently, six aircraft are to be sent to Base #3 and five to Base #4; all are to be withdrawn to the MOBs on day 9.

Base maintenance personnel are described for Bases #1 and #2 with the CT21 cards shown on Fig. 20. Since these bases have identical numbers of personnel, the CT21/88 is used to duplicate the personnel at Base #1 for Base #2. Personnel organization of the two-squadron COMO bases (Bases #1 and #2) is controlled by the CT45/1 cards shown later on Fig. 25; for example, personnel types #1, #2, and #3 in the first squadron are the same types of specialists as personnel #21, #22, and #23 in the second squadron. Personnel #72 and #73 are the same specialists at wing level as #2 and #3 are in the first squadron. Equipment assignments to the squadrons are controlled similarly with the CT46 cards. The kinds of cross-training and task-assist training that the various specialists have received (at those bases specified on CT17/1), are specified with the CT45/2 and CT45/3 cards, also shown on Fig. 25. Personnel types #5 and #4 are cross-trained to handle designated tasks normally performed by personnel type #3.

Equipment stocks are specified with CT22; as for personnel, the equipment at Bases #1 and #2 are to be the same. The CT22/66 and CT22/77 cards provide performance specifications for the three types of AIS stations.

The initial base stocks of spare parts may be entered for each base using the basic CT23, or the user may elect to take advantage of TSAR's automatic parts initialization subroutines by using the other CT23 formats. This example uses automatic parts initialization, augmented with some parts specified with basic CT23, as illustrated in Fig. 21. Although spare parts for battle damage repair can be generated automatically for damage received in combat (see CT15/2), spare parts needed for damage incurred during airbase attack must be provided with CT23; the first four CT23 cards on Fig. 22 provide

such battle damage parts for the four operating bases. Six Type #205 parts are to be stocked at each MOB and two at each DOB.

The policy factors that govern the automatic initialization of spare parts stocks are entered with the CT23/70 and CT23/72 cards, and the NRTS rate for each type of part is entered with the CT23/20x cards for Base #x. These are illustrated for Bases #1 and #3 in Fig. 21. The CT23/70 card was needed for Base #3 to provide the type and number of aircraft for which battle damage spares were to be provided, but the CT23/72 card was not. Unit costs are specified with the CT23/66 cards. Bases to be solicited for lateral resupply are listed with CT23/74 cards. The CT23/78 cards designate the "tray" for each of the parts that are repaired with the AIS equipment.

Initial stocks of assembled and unassembled munitions, TRAP, POL, and building materials are shown in Fig. 21 for some of the bases.

The CT28 cards list those aircraft parts that may be recovered when an aircraft is too badly battle damaged to be repaired. FSALVG on CT3/3 is that percent of parts that can be recovered from an aircraft destroyed by air attack, and "Parts Recovery" on CT15/2 is the percent of parts that can be recovered from an aircraft that is too badly damaged in combat to be repaired. The maintenance "doctrine" (i.e., the order in which on-equipment tasks are performed) at each base is specified with the CT29 cards. Note the minor differences among the bases; how Task #30000 (that denotes ABDR work) is used, and how Shop #30 (return to parent base when complete) is used at the EMERGency base, Base #5. The CT29/88 card specifies that Tasks #61 and #62 are not recognized by the aircrew before recovering at a DOB 80 and 50 percent of the time, respectively.

SHIPPING AND COMMUNICATION

The only shipments scheduled (see Fig. 22) to the theater from CONUS are 12 Type #31 personnel on day 2 at 1900 for Base #1 and a number of unassembled Types #1 and #12 munitions on day 4 at 1100. All other shipments from CONUS during the simulation will be the spare parts in the depot pipelines, or the aircraft, personnel, equipment, and parts that are resupplied after they have been destroyed by air attack, or

```
23  1  205  6           6    0  206  4           4    0
23  2  205  6           6    0  206  4           4    0
23  3  205  2           2    0  206  1           1    0
23  4  205  2           2    0  206  1           1    0
23201    1 70   45   68   19    4   27   85    2   18   66
23201   11 43   28   63        14   10   28             36
23201  101 55   38  101                 101  101
23201  111     101  101  101  101  101  101  101       101
23201  141101  101       101
23203    1101  101  101  101  101  101  101  101  101  101
23203   11101  101  101       101  101  101            101
23203  101101  101  101                 101  101
23203  111     101  101  101  101        12  101
23203  141101  101       101
23 66    1  460   57  186  921   14  780  207   96  107  112
23 66   11   17  162   93   36   49
23 66  101   58   95   47                  36   85
23 66  111        82   44  152   72        51  111
23 66  201  109   67   19   49  112   68
23 66  211   19   27
23 70    1    1    1   15   80  180   72   48   10   20
23 70    3    3    1    4    0    0   72   48   10   20
23 72    1    1  150   75  120   75
23 74    1    2    6    5    4    3
23 74    2    1    6    4    3    4
23 74    3    2    1    6    4    5
23 74    4    1    2    6    3    5
23 74    5    1    2    6
23 74    6    1    2    5
23 78    7    1   10    5    2    3    6    9
23 78  101    4    7
23 78  117    8

24  1    2  160    3  100    4   60    5   80    6  100   11   50
24  1  502 2500  503 2000  504 1000  505 1600  506 2000  511 2500
24  1    1 2000   12  150  512  500
24  1   51 3200   52 4750   53 4800   54 3100   56 5600
24  3    2   40    3   50    4   30    5   20    6   40   11   25
24  3  502  500  503  800  504  400  505  400  506  700  511  500
24  3    1  150   12   50  512  100
24  3   51  770   52 1900   53 1300   54 1200   56  600
25  1    1   72    2   48    3   48    4   48    5 5000
25  3    1   10    2   10    3   10    4   10    5 1000
26         1 6000    2 4500    3 2000    4 3000    5 2000
27         127000    229000    3 7000    4 6400    5 3000    6 8000
28         1    1    2    3    4    5    6    7    8    9   10
28        11   11   12   13   14   15  202  203  205
29  1    1    1   25    030000    2    4    7   42   43   44    0
29  1    1    2    3    5   12   61   62    9   10   26   29    0
29  2    1    1   25    030000   62    2    4    7   42   43   44
29  2    1    2    0    3   12    5   61    9   10   26   29    0
29  3    1    1   25    030000    2    4    7   42   43   44    0
29  3    1    2    3    5   12    9   10   26   29    0    0
29  4    1    1   25    030000    2    4    7   42   43   44    0
29  4    1    2    3    5   12    9   10   26   29    0    0
29  5    1    130000    2    4    7    0    3    5    9   10   29
29  5    1    2   12    0   30    0    0    0    0
29 88    1   61   80   62   50
```

Fig. 21—Parts, munitions, TRAP, building material, and POL stocks and the task sequence lists for several bases

(in the case of parts) condemned or NRTSed during the simulation. The nominal resupply times for these classes of resources are specified by CT33.

The transportation schedules between operating bases (CT32/1) specify that shipments go from each MOB to the other MOB, and to the rear maintenance base, every afternoon, and to the other aircraft bases every other afternoon. The *central supply point* (on Base #10) has daily shipments scheduled to each base each evening. Shipment times among the aircraft bases all are 18 hours, with loss rates of 2 percent (CT32/2). The daily transportation to and from the rear maintenance base (#6) and from the central supply point also takes 18 hours.

CT34 shows that parts NRTSed at the MOBs—Bases #1 and #2—are to be sent to (the depot in) CONUS. The DOBs, the EMERGency recovery base, and the rear maintenance base, however, NRTS some of their parts to one of the MOBs and some to CONUS. CT35/1 provides specific cannibalization times for several types of parts; note that part Types #3 and #6 may be cannibalized only when at least five aircraft (DOCANN = 5) are already NMCS for that part type.

CT35/2 indicates the probability that parts #3, #5, #8, #12, and #15 will be broken during cannibalization; the values range from 8.5 percent for part #5 to 24.0 percent for part #7. CT35/3 restricts parts repair for several parts to the parent facility of a distributed shop. The CT35/4 cards identify which part numbers refer to different locations of an identical physical part; part numbers #16, #18, #19, and #14 refer to four locations of the same physical part on aircraft #1.

CIVIL ENGINEERING TASKS

The reconstruction procedure numbers for runways and taxiways are entered on the first seven (special) CT37 cards; these cards define the procedures that are used for removing UXO and mines from the runways and taxiways and for repairing bomb craters so that flight operations can be resumed. The reconstruction procedures, the chemical characteristics (CWTYPE), and SIZE are specified for all other facilities on the 24 basic CT37 cards on Fig. 23.

The CT37/66 cards indicate that the same steps—#1, #31, and #32—are required to remove either type of UXO, #1 or #2. Repair procedures are specified for runway craters with 5-, 20-, and 35-ft radii on the CT37/77 cards; each is a multistep procedure. Taxiway craters on all bases (BASE = 0) are repaired (CT37/88) with a two-step

31		2	19	1	1	12	31								
31		4	11	1	4	1700	501	4	1000	512					
32	1	1	2	117	1	3	217								
32	1	1	4	217	1	5	217								
32	1	1	6	117											
32	1	2	1	117	2	3	217								
32	1	2	4	217	2	5	217								
32	1	2	6	117											
32	1	3	1	321	3	2	321								
32	1	3	4	217											
32	1	4	1	206	4	2	207								
32	1	4	3	209											
32	1	5	1	217	5	2	217								
32	1	6	1	117	6	2	117								
32	1	10	1	117	10	2	117								
32	1	10	3	115	10	4	116								
32	1	10	5	120	10	6	121								
32	2	1	2	0	0	18	0	98	1	3	0	0	18	0	98
32	2	1	4	0	0	18	0	98	1	5	0	0	18	0	98
32	2	1	6	0	0	18	0	98							
32	2	2	1	0	0	18	0	98	2	3	0	0	18	0	98
32	2	2	4	0	0	18	0	98	2	5	0	0	18	0	98
32	2	2	6	0	0	18	0	98							
32	2	3	1	0	0	18	0	98	3	2	0	0	18	0	98
32	2	3	4	0	0	18	0	98							
32	2	4	1	0	0	18	0	98	4	2	0	0	18	0	98
32	2	4	3	0	0	18	0	98							
32	2	5	1	0	0	18	0	98	5	2	0	0	18	0	98
32	2	6	1	0	0	18	0	98	6	2	0	0	18	0	98
32	2	10	1	0	0	18	0	98	10	2	0	0	18	0	98
32	2	10	3	0	0	18	0	98	10	4	0	0	18	0	98
32	2	10	5	0	0	18	0	98	10	6	0	0	18	0	98
33		1	4 0	6	2	5 0	6	3	8 0	6	8	212	6		
34	1	1	600	11											
34	2	1	600	11											
34	3	1	6	11	13	2	15	11	150	1	240	11			
34	4	1	6	11	13	1	15	11	150	2	240	11			
34	5	1	6	11	13	1	15	11	150	2	240	11			
34	6	1	6	11	13	2	15	11	150	1	240	11			
34	10	1	600	11											
35	1	1	20	2	15	3	-30	4	20	5	24	6	-15		
35	1	7	21	8	24	9	10								
35	1	16	40	18	-1	19	30	143	35	145	-1				
35	2	1	0	0	125	0	85	0	0	240					
35	2	11	0	142	0	0	222								
35	3	7	1	1	1	1	1	1	1						
35	3	117	1												
35	3	134	1	1	0	0	1	1	1						
35	4	1	16	18	19	14									

Fig. 22—Intratheater transportation data, parts disposal data, and special parts treatment data

procedure—#4 and #34. The CT37/99 card indicates that sweeping procedure #2 is used to clear mines on runways, and that manual procedure #3 or sweeping procedure #6 may be used to remove mines from taxiways, depending upon their projected manpower requirements.

The CT37 cards for the other facilities specify their repair procedures and chemical characteristics; for those facilities that are distributed, these locations and their capacities also are designated (e.g., facility #10 is distributed in facilities #101 and #102). Entry delays are listed for the collective-protection shelters, facilities #121 through #126 (although they are irrelevant in this example since USECP is set to 0). For most facilities the base number is not entered, which means that all bases are treated the same; only the two-step shelter repair procedures identified for the three shelter types differ for Bases #1 and #2 (see "facilities" #36, #37, and #38).

The requirements for the various civil engineering repair and recovery procedures specified on CT37 are entered using CT38. Fifteen of the procedures shown in Fig. 23 are used for runway and taxiway clearance of UXO, mines, and craters. Procedure #7 is an alternative for procedures #5 and #21. The other CT38 list the procedures for repairing buildings. As outlined in Sec. VIII, Vol. I, and Sec. XIX, the time and material requirements are relevant for one unit of damage to buildings; the total material requirements are directly proportional to the total number of units of damage, and the repair time is a user-specified function of the total damage.

The priorities for reconstruction at each base are controlled by the entries on CT39. Repair of runways and taxiways always get first and second priority; if sufficient resources are available, the various facilities in these lists are repaired in the order noted. Aircraft shelter repair (#36) has tenth priority at Bases #1 and #2 on CT39.

AIRBASE ATTACK

Several airbase attacks are scheduled to occur in the scenario of the sample problem. Bases #1 and #2 are both attacked shortly after 0600 and again shortly after 0700 on the first day of the simulation. Details of these attacks will be found in the TSARINA user's manual (N-3010-AF) in the description of the sample problem in Sec. VI. The extensive "CT40" cards generated by TSARINA are stored in a separate dataset and are read during initialization when a CT40 card that displays "40888" (such as is shown at the top of Figure 24) or "40777" is encountered. A "777" would specify that

```
37 66     1    1   31    32
37 66     2    1   31    32
37 77     5   23   35
37 77    20    5   33   37
37 77    35   21   36   37
37 88     0    4   34
37 99     0    0    3    2    6
37  0     1 11 5   50  0 0    0     0 0  0    2 11 5   35  0 0    0    0 0  0
37  0     3 11 5   45  0 0    0     0 0  0    5 11 5   75  0 0    0    0 0  0
37  0     7 11 5   60  0 0    0     0 0  0    9 11 5   68  0 0    0    0 0  0
37  0    10 12 4   80101 5    0     0 0  0  101 12 4   5010210    0    0 0  0
37  0    12 11 4   30  0 0    0     0 0  0
37  0   102 12 4   50  010    0     0 0  0                             0 0  0
37  0    28 11 5   50111 5    0     0 0  0  111 11 4   50  0 5    0    0 0  0
37  0    27 11 5   50112 5    0     0 0  0  112 12 4   50  0 5    0    0 0  0
37  0    30 11 5   75  0 0    0     0 0  0
37  0    31 12 2   75 51 1    0     0 0  0   51 12 2   75  0 1    0    0 0  0
37  0    32 12 2   75 52 1    0     0 0  0   52 12 2   75  0 1    0    0 0  0
37  1    36 24 1  100  0 0 145      0 0  0  145 25 1  100  0 0    0    0 0  0
37  2    36 41 1  100  0 0 145      0 0  0  145 26 1  100  0 0    0    0 0  0
37  1    37 42 1  100  0 0 148      0 0  0  148 25 1  100  0 0    0    0 0  0
37  2    37 43 1  100  0 0 148      0 0  0  148 26 1  100  0 0    0    0 0  0
37  1    38 44 1  100  0 0 149      0 0  0  149 25 1  100  0 0    0    0 9  0
37  2    38 45 1  100  0 0 149      0 0  0  149 26 1  100  0 0    0    0 0  0
37  0    40 12 6   40 71 1    0     0 0  0   71 12 6   40  0 1    0    0 0  0
37  0    41 14 3  100  0 0    0     0 0  0                             0 0  0
37  0    44 30 1   10 62 5    0     0 0  0   62 30 1   10  0 5    0    0 0  0
37  0    46 11 5   25  0 0    0     0 0  0   48 11 5   25  0 0    0    0 0  0
37  0   121 14 6  100122 5    0     0 3120  122 14 5  100  0 5    0    0 3120
37  0   123 14 6  100124 5    0     0 2150  124 14 6  100  0 5    0    0 2150
37  0   125 14 6  100126 5    0     0 6140  126 14 6  100  0 5    0    0 6140

38        1 1548192 4     196 1                               7  500   12              REMOVE UXO
38        2 3048191 4196 1195 1                                                        RUNWAY MINES - SWEEP
38        3 3048191 2     197 1                     0                                  TAXIWAY MINES - PICK-UP
38        4 9048191 8192 4194 2197 1  1 2                                              TAXIWAY CRATERS
38        51204819114192 5194 2197 1  1 4  0 0      7         3  300    8   10         RUNWAY CRATERS
38        6 7548191 2196 1195 1                                                        TAXIWAY MINES - SWEEP
38        73304819110192 2197 1                               5  300   12              ALTERNATE RUNWAY CRATER
38       11 7056194 6     198 2       6 1  4 2      0    0
38       12 9058194 8     198 2199 1  4 3  3 2      0  537
38       14 8057194 8  0 0198 1199 1  4 3  2 2      0    0
38       211504819114192 5194 1197 1  1 4  0 0      7                                  RUNWAY CRATERS
38       22 1248193 1
38       23 604819110192 3194 1197 1  1 4  0 0                                         RUNWAY CRATERS
38       24 4052193 2  0 0  0 0  0 0  0 0  0 0      0    0
38       25 1252193 1  0 0  0 0  0 0  0 0  0 0      0    0
38       26 6050192 1
38       27 2449194 1
38       28 4850193 1
38       30 6048200 1
38       31 2148193 1                                        20  750
38       32  948192 2
38       33 4548192 3     197 1
38       34 9048192 3     197 2
38       35 2448192 2     197 1
38       36 9048192 4     197 3
38       37 1548192 1
38       41 3048193 3
38       42 4050193 2  0 0  0 0  0 0  0 0  0 0      0    0
38       43 6050193 3
38       44 4052193 2  0 0  0 0  0 0  0 0  0 0      0    0
38       45 9048193 3
39  1     1    1   10   12    7    5    3    2    9   30   36
39  1    11   46   48   71   40   41  121  123  125   31   32
39  1    21  101   51   52   28   27  111  112  122  124  126
39  1    31  102   44   62
39  2     1    1   10   12    7    5    3    2    9   30   36
39  2    11   46   48   71   40   41  121  123  125   31   32
39  2    21  101   51   52   28   27  111  112  122  124  126
39  2    31  102   44   62
```

Fig. 23—Facilities data, civil engineering task data, and civil engineering repair priorities

the damage data for Trial #1 should be used for all TSAR trials. The "888" in columns 3–5 for the sample problem specifies that different damage data are to be input for each trial. (If the number of TSARINA trials is fewer than the number of TSAR trials, the TSARINA data will be reused as required. For example, a five-trial TSAR run with three trials of TSARINA results would reuse TSARINA Trials #1 and #2 for TSAR Trials #4 and #5.) In the sample problem the attacks differ at each base; the second attack at Base #1 uses chemical weapons, whereas the first attack at Base #2 uses chemical weapons.

EFFECTS OF CHEMICAL WEAPONS

The CT43 and CT44 cards on Figs. 24 and 25 include the data that define how TSAR is to calculate the effects of the chemical ensembles and the toxic effects of chemical weapons. Only one chemical protection ensemble is included in the sample problem; the different amounts of it that may be worn are defined as MOPP #1 to #5. The heat transfer properties for each MOPP are entered with the CT43/1 cards, the ambient weather conditions for meteorological conditions #1 and #5 with the CT43/2 cards, and the slowdown effects for various MVDC factors with the CT43/3 cards. Times to get into the different MOPP are entered with the CT43/4 cards, hospitalization times with the CT43/5 cards, and assignment and entry time data for collective-protection facilities with the CT43/6 Cards. The specific factors used to control the estimation of excessive sweating, wetting, and dehydration are specified with the CT43/7 and CT43/8 cards.

The chemical characteristics of the several facility types are entered with the CT44/1 card and its supplementary cards shown on Fig. 25; the CWTYPE of each TSARINA target type is identified with the CT44/2 cards. The CT44/3 cards, and their supplementary cards, define the chemical concentrations that will cause fatalities, casualties, and ocular degradation for each agent-MOPP combination. At this time, TSAR does not assess the effects of ocular degradation. The CT44/4 cards define which MOPP is worn when there is chemical contamination on an airbase. The CT44/5 controls which personnel are selected to provide "buddy-care" when members of the casualty's work team are insufficient; personnel types #1, #4, . . . , and #65 may be selected. (Except that these data are irrelevant since DOBUDY is zero for the sample problem.)

```
40888
41  1 1 16   8
41  2 1 16   8
43  1    1  350  350  350  350  360
43  1    2  250  250  250  270  200
43  1    3 1700 1650 2240 2160 2650
43  1    4  476  440  330  240  280
43  2    1    1  -45  -48  -53  -58  -60  -65  -66  -66  -61  -55  -52  -48
43  2    1    2   80   78   76   70   54   50   50   50   52   60   64   66
43  2    1    3   30   32   36   40   32   24   20   15   18   20   24   30
43  2    5    1  -57  -58  -62  -66  -69  -73  -75  -74  -68  -64  -62  -60
43  2    5    2   85   80   78   73   64   58   56   57   59   66   76   78
43  2    5    3   20   22   24   30   32   34   27   20   16   14   18   20
43  3    1  110  131  131  131  131
43  3    2  110  124  124  124  124
43  3    3  110  140  140  140  140
43  3    4  110  155  155  155  155
43  3    5  110  125  125  125  125
43  3   10  100  100  100  100  100
43  3   11  108  117  112  129  134
43  3   17  116  126  132  138  141
43  3   33  112  121  122  126  131
43  4    1   20    4    6    0    0
43  4    2   15    0   15    0    0
43  5    1   24   28   34   40   48   60   78   86   98  120
43  5    2   48   60   72   96  120  150  180  210  240  300
43  5    3   72   96  120  150  180  210  250  300  380  480
43  6    1  121 24 6  123 30 6  121 15 6  125 18 6
43  6    2  121 24 6  123 30 6  121 15 6  125 18 6
43  7   60   50 2000   20    5
43  8   60  150 1250  850  500  250   60  300 2000 1000  850  400
```

Fig. 24—Aircraft initialization data and data that specify task slowdown and rest requirements in CW environment

The CT47 cards define the administrative delays for parts repairs and equipment repairs at the various shops. The mean delays range from 4 to 22 hours; realized delays are drawn from a distribution (#6 in all cases but one). The CT49 cards control changes to various parameters as a function of the simulation time. In the sample problem they change only the value of three key output control variables one hour before the end of the simulation; these changes provide extensive output at the end of the simulation, without producing extensive listings at early times during the 12 days.

Following CT1 through CT49, as discussed above, the CT99 signals that all input data except the flight demand data have been entered.

FLIGHT DEMANDS

Only periodic flight demands are used in the sample problem. (See Sec. XIX for the other options.) Each CT50 shown on Fig. 26 for Bases #1 and #2 calls for four flights of three aircraft during one of four 90-minute time blocks each day. The first card calls

```
44  1    6
         1    0    0         1         1
         2    0    6        10         1
         3   18   30     10000        10
         4    0   15     10000         1
         5    0   20     10000         1
         6 2020   60     10000        20
44  2    1    1    2    1    1    5    2    4    6    2    6
44  2   11    3    1    1    1    3
44  3    1    1
         1       400       0.2       200       0.2
         2      3000       0.2      1500       0.2
         3        50       0.2        25       0.2
44  3    1    2
         1      1000       0.2       500       0.2
         2      5000       0.2      2500       0.2
         3   1000000       0.2    500000       0.2
44  3    1    3
         1     10000       0.2      5000       0.2
         2     80000       0.2     40000       0.2
         3        50       0.2        25       0.2
44  3    1    4
         1     25000       0.2     12500       0.2
         2    150000       0.2     75000       0.2
         3   1000000       0.2    500000       0.2
44  3    1    5
         1     25000       0.2     12500       0.2
         2    150000       0.2     75000       0.2
         3   1000000       0.2    500000       0.2
44  4    1    1    1
      4275    5       171    2         0    1
44  4    1    2    1
       0.7    5     0.025    2         0    1
44  5    1 60 6    0    1    4    6    7   62   64   65    0    0
44  5    2 60 6    0    1    4    6    7   62   64   65    0    0
44  5    3 60 6    0    1    4    6    7   62   64   65    0    0
44  5    4 60 6    0    1    4    6    7   62   64   65    0    0

45  1    1   21              2   22        72    3   23        73
45  1    4   24        74    5   25        75    6   26
45  1    7   27        77    8   28        78
45  2    3    5    4
45  2   64   65
45  2   65   64
45  2   72   74   75   77
45  2   74   73   74   78
45  2   75   73   78
45  2   77   78
45  2   78   75   77
46       2   12        22    5   15        25
46      80   81              85  86
47       1 12 6 18 6 16 6 12 6 14 6 22 6  8 6  9 6 12 6 16 6
47       3 18 6 12 7  8 6 14 6  9 6 19 6  8 6  4 6 19 6  8 6
49    1223  4 1   28 1223  4 2   28 1223  4 3    5
99
```

Fig. 25—Chemical toxicity data, cross-training data, and administrative delay data

for four three-ship flights to be launched on mission #1 between 0600 and 0730 from Base #1. The base has an eight-hour notice of these demands and two aircraft are acceptable in each flight if three are not available. Each day, 16 flights are to be launched on mission #1, and 16 flights on mission #2 from Base #1.

Base #2 has identical demands. In addition, the aircraft maintained at the dispersed operating bases (#3 and #4) will attempt to launch up to 12 two-ship flights from each base each day. These flight demands at the DOBs are terminated after day 10 (see the "99 10" card image), using the eight periodic flight demand cards with null entries.

```
50  1   1   1   1   1       3   2   8          600   4  130
50  2   1   1   1   3       3   2   8          930   4  130
50  3   1   1   1   1       3   2   8         1300   4  130
50  4   1   1   1   3       3   2   8         1900   4  130
50 17   1   1   2   1       3   2   8          600   4  130
50 18   1   1   2   3       3   2   8          930   4  130
50 19   1   1   2   1       3   2   8         1300   4  130
50 20   1   1   2   3       3   2   8         1900   4  130
50  5   2   1   1   1       3   2   8          600   4  130
50  6   2   1   1   3       3   2   8          930   4  130
50  7   2   1   1   1       3   2   8         1300   4  130
50  8   2   1   1   3       3   2   8         1900   4  130
50 21   2   1   2   1       3   2   8          600   4  130
50 22   2   1   2   3       3   2   8          930   4  130
50 23   2   1   2   1       3   2   8         1300   4  130
50 24   2   1   2   3       3   2   8         1900   4  130
50  9   3   1   1   1       2   1   8          600   3  130
50 10   3   1   1   3       2   1   8          930   3  130
50 11   3   1   1   1       2   1   8         1300   3  130
50 12   3   1   1   3       2   1   8         1900   3  130
50 13   4   1   1   1       2   1   8          600   3  130
50 14   4   1   1   3       2   1   8          930   3  130
50 15   4   1   1   1       2   1   8         1300   3  130
50 16   4   1   1   3       2   1   8         1900   3  130
99 10
50  9
50 10
50 11
50 12
50 13
50 14
50 15
50 16
99 60
/*
```

Fig. 26—Flight demand data

XXI. SAMPLE CALCULATION—OUTPUTS

As explained in Sec. XV, Vol. I, TSAR provides the user with a rich variety of output options. This section illustrates most of those options with reproductions of the results of the sample problem presented in Sec. XX. The primary omissions are the user options for generating customized output and for storing selected data on disk for post-processing (discussed in Secs. XV.3 and XV.4).

Figures 27 and 28 display the formatted "title" pages that summarize the user-specified values for many of the control variables. A 12-day simulation is to be run for three trials. Four operating bases and three other bases are involved in the simulation. A variety of other control variables are recorded in the upper and center sections. Key array dimensions are listed at the bottom. As noted earlier, there are two optional controls over the reproduction of input data. The user may specify (on the first card in the input deck) that some or all of the input card images are to be echoed immediately, and/or may direct that the input data are to be listed after they have been processed for the storage arrays (on the card after the first CT99); neither of these options will be illustrated in this section. (See Fig. 1 in this volume.)

Figure 28 is printed when USECW > 0 and displays most of the factors that control TSAR's handling of the effects of chemical warfare. The user's selections for the key control values are listed at the top left, and the default values for the heat factors for the five generic task types are listed at the upper right. The thermal characteristics of the MOPP levels and the times that are needed to don them are displayed next, as are the user's specifications of the wetting, perspiration, and dehydration limits (the Vogt constraints). The portions of the ensemble (MOPPs) that are to be worn by personnel doing various tasks before the first attack are listed at the right under the generic tasks. Certain key characteristics of the airbases and the CPSs at those bases are listed next; the CPS data are listed by generic task type, except that the same personnel shelters are used both for flight-line and preflight personnel, and none need be specified for off-duty personnel. The temperature and the chemical protection characteristics of each CW facility type (CWTYPE) are given next on the left, and the ten-step distributions of hospitalization times for heat exhaustion, conventional casualties, and chemical casualties are on the right. (Note that CWTYPE #1 always applies to outdoor areas and

```
*****************************************************************************************************************
                                       *************************          JULY  3, 1989       02:20 AM
                                       THE 'T S A R' SIMULATION
                                       *************************          RUN ID#26995

                     THEATER SIMULATION OF AIRBASE RESOURCES AND SORTIE GENERATION IN WARTIME

                                    DEVELOPED AT THE RAND CORPORATION
                                     FOR THE UNITED STATES AIR FORCE
                                            BY D. E. EMERSON

  BASES : OPERATING 4  OTHER 3       SIMULATION LENGTH  12 DAYS          NUMBER OF TRIALS   3          EXTEND 0
  ****************************      **************************          *******************           PMODE  0
                                                                     DEFINE PARTS 1  SHORTAGE  12%   PIPELINE 1  RANDM 1
                                                                     CRITICAL SHORTAGES  -0.1 %  (0.72-0.94)
ORDER INTERRUPTED TASKS      1     INITIAL AIRCRAFT    48          CANNIBALIZATION MODE          2
ORDER WAITING TASKS          1     INITIAL CREWS       96          LEAST DOWN TIME TO CANN       4 HRS
DEFER NON-CRITICAL TASKS     1                                     CANN TIME IS  150% NOMINAL PLUS   0 MIN DELAY
REFUEL SEPARATELY            0     SEED                 7          MAX HOLES PER AC   10      "DOCANN"     5
OVERFLOW CONTROL             2     TRIAL   0    TEST  0 (    0     0)   CANNIBALIZE SRUS   4

    END NOMINAL FLYING DAY  20:00                                  CREW OFF DUTY 12 HRS        PRINT            2
    COMMENCE UPLOAD (NOM)    2:15    ALLOWABLE OVERTIME       0 MIN   GROUND TIME    30 MIN       VERIFY           0
                    (LAST)   4:45                                  REPORTS         0 (  50)    DELAY DATA       30 DAYS
                                                                   START REPORTS 0.2 DAYS      STORE STATISTICS 0
    ASSEMBLE MUNITIONS         1     BREAK-RATES: UNCER  8  VARIABLE 0   IGNORE DEFERRABLE TASKS 0   PRINT PARTS      8
                      SHIPPING DATA                                          AIRBASE ATTACK FACTORS
                      *************                                          **********************

CONUS SHIPMENTS         200(5000)    RESUPPLY SHIPMENTS      4000      FACILITIES/BASE 250          REBUILD        1
THEATER SHIPMENTS                                                  CE PERSONNEL     20          ATTACKS      100
    PREPARATION TIME  480 MIN             DAILY NOMINAL          30      CE EQUIPMENT     20          DAMAGE DATA20000
    MAXIMUM PACKAGES 5000                 MAXIMUM               200      CE MATERIALS     50
                                          MAXIMUM STORAGE       200      CE DELAYS        30 MIN      SHOP DELAYS    60 MIN
                                              RESOURCE MANAGEMENT
                                              *******************
                                            THEATER CONTROL MODE   20
THEATER MANAGEMENT        1      INITIAL REVIEW TIME1500 HRS     CONCURRENT DAMAGE REPAIR   0      EXPEDITE PARTS REPAIR      7
TSAR CONTROL MODE         4      REVIEW INTERVAL      12 HRS     REAR MAINTENANCE CONTROL   2      SHIP PARTS WHERE NEEDED    1
                          0      REVIEW POLICY         0         FILLER CONTROL             3      RR PARTS NRTS THRESHOLD    0%
TSAR ORDER THRESHOLD      0      BASE ORDER THRESHOLD  0         FILLER LEVEL               2      SHIP IF SHOP DAMAGED       1
PRIORITIZATION MODE       0      CONSIGN PARTS         1         FILLER CALL THRESHOLD    0.0 HRS  SHIP IF SRU NOT STOCKED    0
ASSESS BASE STATE         0      SELECT RECOVERY BASE -1         AC ROTATION THRESHOLD   10.0 HRS  HOLD REPARABLE TO SHIP     0
                                                                      (     40    150)
                                          DIMENSIONS OF STORAGE ARRAYS
                                          ****************************

AIRCRAFT   600             PERSONNEL TYPES 200          TASKS          1000               REPAIRS        400
AIR CREWS1000              PARTS          5000          INTERRUPTED     400               WAITING       8000
BASES       10             AGE & EQUIPMENT 200          REQUIRED       5000               DEFERRED     10000
AC TYPES     9             MUNITIONS       200          ADMIN DELAY    2500               NOR           4000
MISSIONS     5             TRAP             50          INCOMPATIBLE    240               FLIGHTS       1000

TASK TYPES  7500       REPAIR TYPES5000      AGE REPAIRS  500       CE REQTS  200       STANDARD COMBAT LOADS  50
ALTERNATES  1000       ALTERNATES   500      AMMO ASSEMBLY100       CE TASKS 1000       CONFIGURATIONS         50
*****************************************************************************************************************
```

Fig. 27—Key TSAR control variables

CWTYPE #2 always applies inside aircraft shelters.) Finally, Fig. 28 lists the thresholds that determine what portion of an ensemble (MOPP) will be worn.

Figure 29 is a portion of the parts initialization summary. The first lines show the costs of the battle damage spares that have been provided for the four combat bases; the "actual" costs reflect shortages specified on CT3/3. The factors that determine shortages are summarized on the next line. Those spares for which the shortage exceeds 12 percent (as a result of the TOOFEW value on the same card) are listed next; for example, parts #4 and #6 are short by 32.9 and 25.1 percent, respectively. The parts procurement policy factors, the delivery schedule for the spare parts in the base-CONUS-base pipeline, and the initial stock levels are then listed for Bases #1, #3, and #6. Note that stocks for Base #1 are based on only 15 aircraft even though 24 are assigned, and that parts for Base #3 include only the battle damage spares for 4 aircraft, since the peacetime and wartime sortie rates are zero. The pipeline data are formatted in the manner specified for CT31. The parts in the pipeline are distributed over the ten-day order-and-ship time specified on the CT23/70 cards; all deliveries are delayed by seven days (HIATUS = 7). On the eighth day, two LRUs and one SRU are due in—one Type #6 part, one Type #16, and one Type #144 SRU. Because the theater manager was directed to control distribution of incoming parts (CONSIG=1 on CT1), the parts are consigned to Base #10 (MAXB), the base reserved for the theater manager when the parameter TSAR is initialized greater than zero. The parts stockage data for each base includes the part number, the number of servicable parts on base, and the base's "authorized" number. For example, there are 25 servicable Type #1 parts on Base #1, and 33 are authorized.

The output available at the time of an attack with chemical weapons is illustrated in Fig. 30. These are the results of the second attack on Base #1, at 0718 on day 1. The first display shows the chemical contamination after the attack at each of the monitoring points. Liquid chemical intensities are listed in the first column; liquid chemicals fell on 16 of the 30 monitoring points. The times after the 0718 attack time that chemicals arrived at the monitoring points (to the closest minute) are listed in the last column; the heavy deposits fell quickly and reached several monitoring points within 30 seconds. The lighter droplets landed after one or two minutes.

There were ten aircraft on base at the time of the attack (eight of them in shelters); one of the exposed aircraft was destroyed and one of the sheltered aircraft was damaged. Three of the aircraft shelters were damaged. Civil engineering work that is ongoing at

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**************************************************************************************************
                                        T S A R
              SIMULATION OF AIRBASE OPERATIONS IN A CHEMICAL WARFARE ENVIRONMENT
                    DEVELOPED BY DONALD E. EMERSON AND LOUIS H. WEGNER
                                 AT THE RAND CORPORATION
**************************************************************************************************

USE CW  2                IWARN    -5 MIN   WORK LIMIT 38.80 DEG   CWFREQ  2 HRS    FLIGHT  PRE   BACK  MUNITIONS CIVIL  OFF
USE CP  0   VARMOP  1     WARN    -2 MIN   DELTA       0.50 DEG   CPRINT  0         LINE  FLIGHT SHOPS  ASSEMBLY ENGIN  DUTY
REMOTE  0   NOVOGT  0    AGENTS    1       ACCLIMATIZED   0 DAYS  RELAX  60 MIN
            MXHEAT 50    MXTLOS2000        LOOSE MASK   0.5 %                         DEFAULT HEAT FACTORS
                                                                                   118   221    316    424    529
MOPP LIMITS:   ENSEMBLE #1:  1   5   ENSEMBLE #2:  0   0   ENSEMBLE #3:  0   0

               ENSEMBLE CHARACTERISTICS                           VOGT THERMAL LIMITS
  ****************************************************      ************************************
MOPP  SKIN   GAMMA   CLO     IM     DONN    DONN      HEAT    MAXIMUM     WETTING    HYDRATION
      TEMP                          ATTMOP  MASK      LIMIT   SWEATING    LIMITS       LOSS          PRE-ATTACK ENSEMBLES
                                    (MIN)   (SEC)             REST  WORK  W1    W2
  1   35.0   0.250   1.258  0.643    20      15        60     150   250   0.85 0.50    1250      3    3    1    1    1    1
  2   35.0   0.250   1.221  0.594     4       0        60     300   400   1.00 0.85    2000      0    0    0    0    0    0
  3   35.0   0.250   1.657  0.445     6      15                                                  0    0    0    0    0    0
  4   35.0   0.270   1.560  0.332     0       0
  5   36.0   0.200   2.082  0.356     0       0

                          AIRBASE CHARACTERISTICS                                        COLLECTIVE PROTECTION FACILITIES
BASE  SHELTERS  ARCS   NODES   RAMPS  MONITOR  RUNWAYS      HOT PIT ARCS       CW        FACILITY NUMBER/ENTRY TIME (MIN)
                                      POINTS   (OVERRIDE)                   ENSEMBLE
  1      24      45     42      2      30       2           20    43    0      1        121  24    123  30  121  15  125  18
  2      24      45     42      2      30       2           20    43    0      1        121  24    123  30  121  15  125  18
  3       0       0      0      1       0       0            0     0    0      1          0   0      0   0    0   0    0   0
  4       0       0      0      1       0       0            0     0    0      1          0   0      0   0    0   0    0   0
  5       0       0      0      1       0       0            0     0    0      1          0   0      0   0    0   0    0   0
  6       0       1      1      1       0       0            0     0    0      1          0   0      0   0    0   0    0   0

             FACILITY CHEMICAL PROTECTION PROPERTIES                                 HOSPITALIZATION TIME DISTRIBUTIONS
CWTYPE  TEMP    AIR          FILTER FACTORS:   LIQUID / VAPOR                    HOURS FOR 10(10)100 PERCENT OF THE CASUALTIES
              EXCHANGE     AGENT #1           AGENT #2          AGENT #3
                TIME
  1      0.      0.         1./      1.       1./     1.        1./     1.       24   28   34   40   48   60   78   86   98  120
  2      0.      6.        10./      1.       1./     1.        1./     1.       48   60   72   96  120  150  180  210  240  300
  3     18.     30.     10000./     10.       1./     1.        1./     1.       72   96  120  150  180  210  250  300  380  480
  4      0.     15.     10000./      1.       1./     1.        1./     1.        0    0    0    0    0    0    0    0    0    0
  5      0.     20.     10000./      1.       1./     1.        1./     1.        0    0    0    0    0    0    0    0    0    0
  6   2020.     60.     10000./     20.       1./     1.        1./     1.

                                CONTAMINATION LEVELS FOR INDIVIDUAL PROTECTION
 AGENT #1          ENSEMBLE #1                           ENSEMBLE #2                          ENSEMBLE #3
          LIQUID                 VAPOR            LIQUID             VAPOR             LIQUID             VAPOR
LEVEL  MOPP  INTENSITY     MOPP  INTENSITY    MOPP  INTENSITY    MOPP  INTENSITY    MOPP  INTENSITY    MOPP  INTENSITY
  1     5    4275.0000      5     0.7000       0     0.0000       0     0.0000       0     0.0000       0     0.0000
  2     2     171.0000      2     0.0250       0     0.0000       0     0.0000       0     0.0000       0     0.0000
  3     1       0.0000      1     0.0000       0     0.0000       0     0.0000       0     0.0000       0     0.0000
  4     0       0.0000      0     0.0000       0     0.0000       0     0.0000       0     0.0000       0     0.0000
  5     0       0.0000      0     0.0000       0     0.0000       0     0.0000       0     0.0000       0     0.0000
**************************************************************************************************
```

Fig. 28—Key factors for assessing impact of chemical warfare

```
BATTLE DAMAGE SPARES -- COSTS BY BASE --  (THOUSANDS)   ACTUAL:     440   465   157   155     0     0
                                                     AUTHORIZED:    516   516   167   167     0     0

PARTS SHORTAGE FACTORS      12 %     -0.1 %      72      22
         ITEM       4   PERCENT SHORT  0.329
         ITEM       6   PERCENT SHORT  0.251
         ITEM       9   PERCENT SHORT  0.192
         ITEM     112 . PERCENT SHORT  0.301
         ITEM     204   PERCENT SHORT  0.181

 ***  OUTFIT = 1  RANDM = 1  SWITCH = 1   ***   USERS SPECIFICATIONS MAY HAVE BEEN CHANGED

CIRF: 0    OUTFIT: 1   KIND: 1    PMODE  0

BASE STOCKAGE CONDITIONS: BASE # 1  KIND # 1   NO SRUS: 0   TYPE AC  1   NO AC  15  SHORTAGE   12%
                ALPHA 1.50 0.75  BETA 1.20 0.75
                REPAIR TIMES (P-W):  3.0  2.0   ORDER/SHIP TIMES (P-W):   10.   20.  TRAVEL TIME:   0.0  SORTIE RATES (P-W):  80 180

      COST OF PARTS FOR BASE # 1   ACTUAL $    4312   TOTAL $    5204 (THOUSANDS)   LRUS   3787   4624  SRUS   525   580

        PARTS PIPELINE FOR BASE #1
    8   17   10    3    1    6    3    1   16    3    1  144    0    0    0
    9   17   10    3    1    1    3    1    2    3    1    6    3    1  141
    0    0    0    3    1  144    0    0    0    0    0    0    0    0    0
   10   17   10    3    1    7    3    1   16    3    1   20    3    1  107
    0    0    0    3    2  141    0    0    0    0    0    0    0    0    0
   11   17   10    3    1    1    3    1   20    3    1  108    3    2  141
   12   17   10    3    1    2    3    1    6    3    1  141    0    0    0
   13   17   10    3    1    3    3    1   10    3    1   20    3    1  141
   14   17   10    3    1   17    3    3  141    3    1  142    0    0    0
   16   17   10    3    1  108    3    1  141    0    0    0    0    0    0
   17   17   10    3    1  101    3    1  107    3    1  108    3    1  141
    0    0    0    3    1  144    0    0    0    0    0    0    0    0    0

            PARTS AT BASE # 1

    1    2    3    4    5    6    7    8    9   10   11   12   13   15   16   17   20  101  102  103  107  108  112  113  114
   25   13   10    6    3    7    4    7    6   10    5    5    5    6   12   13   24    5    3    3   16   26    1    2    3
   33   17   13    9    3   12    7    9    7   11    6    5    5    7   15   17   29    6    4    3   18   32    2    3    3

  115  117  118  141  142  144  201  202  203  204  205  211  212
    2    2    1   39   18   11    3   14   24   30    4   23   22
    3    2    1   57   24   15    5   15   28   33    4   28   28

CIRF: 0    OUTFIT: 1   KIND: 2    PMODE  0

BASE STOCKAGE CONDITIONS: BASE # 3  KIND # 2   NO SRUS: 0   TYPE AC  1   NO AC   4  SHORTAGE   12%
                REPAIR TIMES (P-W):  3.0  2.0   ORDER/SHIP TIMES (P-W):   10.   20.  TRAVEL TIME:   0.0  SORTIE RATES (P-W):   0   0

        PARTS PIPELINE FOR BASE #3

            PARTS AT BASE # 3

  201  203  204  205  211  212
    2    9    9    1    8    8
    2    9   10    1    9    9

        PARTS PIPELINE FOR BASE #6
   12   17   10    3    1  141    0    0    0    0    0    0    0    0    0
   14   17   10    3    1  141    0    0    0    0    0    0    0    0    0
   17   17   10    3    1  141    0    0    0    0    0    0    0    0    0

            PARTS AT BASE # 6

    1    2    3    4    6    7    8    9   10   11   15   16   17   20  101  107  108  141  142  144  202  203  204  211  212
    6    4    2    2    2    2    2    2    2    0    2    4    4    6    2    4    6    7    4    2    2    5    8    5    5
    6    4    2    2    2    2    2    2    2    2    2    4    4    6    2    4    6   12    6    4    2    6    8    6    6
```

Fig. 29—Summary of the spare parts generated by TSAR

the time of an attack must be stopped, and the record indicates that two UXO removals on arc #1 were stopped when they were 87 percent complete (see the discussion for Fig. 33 for fuller explanation).

Fifteen UXO, 264 mines, and two runway craters must be cleared on the main runway (runway #1) before an MOS (50 × 2500 ft in this problem) will be available. Although there were fewer UXO and no mines to be cleared on runway #2, there were three craters, and the MOS location is to be selected on the basis of the fewest craters (TSKRWY = 0 on CT1). The disruption caused by UXO, mines, and craters on the taxiway network was sufficient to prevent all the shelters from accessing the MOS without taxiway clearance. Twenty-seven persons were casualties from this attack, of which 18 were hospitalized and will eventually return to duty. The numbers of each personnel type that were killed and hospitalized are noted next; of the eight Type #26 personnel casualties, for example, six were hospitalized from conventional weapon effects, and one from chemical effects (therefore one was killed). Two pieces of equipment and 335 munitions also were lost in the attack. The times at which the various types of activity are to be resumed are printed next. The intervening time is assumed to be required to fight fires and to carry out minimum emergency repairs to utilities, roads, and communications, as well as to survey the base to find the MOS. (If UXO and mines are not explicitly represented in the attack data, and in the CT37 and CT38 information, the delays must include an allowance for these problems.)

The resources that survive the attack are listed next. The numbers of personnel on base (excluding those that have been hospitalized), are listed under their personnel type number. The surviving quantities of equipment, munitions, TRAP, and building materials are also listed by type; aggregate surviving quantities are provided for air crews, POL, aircraft shelters, and spare parts.

The data that can be requested (see CPRINT on CT3/4) at the time of each update of the chemical contamination are illustrated in Fig. 31. The density of liquid on the surface and vapor concentration are listed at each monitoring point for each agent. The number of the MOPP that personnel should wear in each facility, in each aircraft shelter, on each ramp, and on each taxiway can also be listed as shown at the bottom of Fig. 31.

Figure 32 lists the results of a conventional attack at Base #1, as well as the regular activity reports for day 1 that TSAR generates when PRINT = 2. This attack occurred at 1215 on day 1; ten aircraft were on-base and all were sheltered. No aircraft

```
DAY  1 TIME  718:     BASE # 1 SUSTAINED AN AIR ATTACK.

DROPLET DENSITY DUE TO ATTACK AND CUMULATIVE VAPOR CONCENTRATION BY AGENT (MG/M*M  --  MG/M*M*M) ON BASE  1 AT  718
                                                                                          ARRIVAL
  N P          AGENT #1               AGENT #2               AGENT #3          TIME (MIN)
   1     2595.00     1.035       0.00     0.000       0.00     0.000               0
   2       21.00     2.240       0.00     0.000       0.00     0.000               2
   3      276.00     0.257       0.00     0.000       0.00     0.000               0
   4       63.00     2.618       0.00     0.000       0.00     0.000               2
   5      276.00     0.047       0.00     0.000       0.00     0.000               0
   6       21.00     2.062       0.00     0.000       0.00     0.000               1
   8     2850.00     3.395       0.00     0.000       0.00     0.000               0
   9       21.00     0.347       0.00     0.000       0.00     0.000               2
  10       21.00     1.593       0.00     0.000       0.00     0.000               1
  11        0.00     0.000       0.00     0.000       0.00     0.000
  12        0.00     0.008       0.00     0.000       0.00     0.000               2
  13        0.00     0.000       0.00     0.000       0.00     0.000
  14        0.00     0.000       0.00     0.000       0.00     0.000
  15        0.00     0.000       0.00     0.000       0.00     0.000
  16     2850.00     7.600       0.00     0.000       0.00     0.000               1
  17     2850.00     1.131       0.00     0.000       0.00     0.000               0
  18        0.00     0.000       0.00     0.000       0.00     0.000
  19        0.00     0.000       0.00     0.000       0.00     0.000
  20        0.00     0.000       0.00     0.000       0.00     0.000
  21     2595.00     3.762       0.00     0.000       0.00     0.000               0
  22        0.00     0.000       0.00     0.000       0.00     0.000
  23        0.00     0.000       0.00     0.000       0.00     0.000
  24     2574.00     0.640       0.00     0.000       0.00     0.000               0
  25        0.00     0.000       0.00     0.000       0.00     0.000
  26      297.00     3.971       0.00     0.000       0.00     0.000               1
  27     2574.00     0.565       0.00     0.000       0.00     0.000               0
  28     2595.00     0.687       0.00     0.000       0.00     0.000               0
  29        0.00     0.000       0.00     0.000       0.00     0.000
  30        0.00     0.000       0.00     0.000       0.00     0.000
         OF  10 (  8) ON BASE AIRCRAFT  1 ( 0)  WERE DESTROYED AND  1( 1)  WERE DAMAGED.    0/ 3 SHELTERS WERE KILLED/DAMAGED.
STOP TAXIWAY CLEARANCE BASE 1 TTU:  139  146 ARC  1 KIND 1 INDEX 42 FCOMP1  0 FCOMP2  87 UNSTARTED REPAIRS   0    0    0
STOP TAXIWAY CLEARANCE BASE 1 TTU:  139  146 ARC  1 KIND 1 INDEX 42 FCOMP1  0 FCOMP2  87 UNSTARTED REPAIRS   0    0    0
                        RUNWAY #1 HAS    15 UXO,   264 MINES, AND   2 CRATERS TO BE CLEARED FOR AN MOS
                        RUNWAY #2 HAS     7 UXO,     0 MINES, AND   3 CRATERS TO BE CLEARED FOR AN MOS
DAY  1 TIME  718 BASE 1:  15 UXO, 264 MINES, AND   2 CRATER REPAIRS ARE REQUIRED FOR RUNWAY #1 (AT  1000 100) MCL,MCW = 2500   50
  0 % OF THE SHELTERS HAVE ACCESS TO THE RUNWAY
                 *****   MOS IS ESTIMATED TO BE AVAILABLE AT BASE # 1 ON DAY  1 AT 1730   *****
 27 PERSONNEL WERE CASUALTIES OF WHICH   18 WERE HOSPITALIZED.         OF   0 LOST AIR CREWS   0 WILL RECOVER.
    MATERIAL LOSSES:   EQUIPMENT   2     SPARE PARTS    0     MUNITIONS  335

              NUMBERS OF PERSONNEL CASUALTIES BY TYPE

       21    22    23    24    25      26    27    28    77   193
        6     2     1     2     1       8     2     2     1     2
        4     2     1     1     1       6     1     0     1     0
        0     0     0     0     0       1     0     0     0     0


MAINTENANCE ACTIVITIES WERE DELAYED UNTIL  921 AND FACILITY RECONSTRUCTION WAS DELAYED UNTIL  951 FOR POST-ATTACK CLEAN-UP
CRATER REPAIRS ON THE RUNWAYS AND TAXIWAYS WILL BEGIN AT  742 AFTER THE ALLOWANCE FOR SURVEY, EOD, AND MINE REMOVAL
                                       RESOURCES AT BASE # 1

                                           SHOP CAPACITY
1000 1000 1000 1000 1000    1000 1000 1000    0 1020    1000 1000 1000 1000 1000    1000 1000 1000 1000 1000    1000 1000 1000 1000
PERSONNEL    1    2    3    4    5    6    7    8   21   22   23   24   25   26   27   28   31   32   63   64   65   72   73   74
            48   16   10   12    8   32    8    8   42   14    9   10    7   24    6    6   20   10   20   80   88   10    4    4
PERSONNEL   75   76   77   78  191  192  193  194  196
             4    5    4    8   90   96   14   40    6
EQUIPMENT    2    3    4    5    6    7    8   12   15   16   17   18   20   21   22   23   25   28   30   31   32   34   80   81
             4    3    5    4    2    2    2    4    4    1    2    2    4   18    4   10    1    2    5    8    6    3    4    3
EQUIPMENT   85   86  194  195  196  197  198  199
             1    1   12    3    3    7    7    3
MUNITIONS    1    2    3    4    5    6   11   12   51   52   53   54   56
          4838 2636 2039 1051 1637 2100 2381 3000 3700 5250 5800 3600 5600
   TRAP      1    2    3    4    5
            44   33   34   34 4698
MATERIALS    1    2    3    4    5
          5000 4500 2000 3000 2000

 AIR CREWS   45   SURVIVING POL  27000   SPARE PARTS: LRU  161 SRU  210     AIRCRAFT SHELTERS: SURVIVED  24  DAMAGED  3
 CUMULATIVE AIRCRAFT KILLED / DAMAGED DURING AIRBASE ATTACKS     1    1
```

Fig. 30—Full listing for a conventional-chemical attack at Base #1

RESIDUAL LIQUID DEPOSITION DENSITY AND VAPOR CONCENTRATION BY AGENT (MG/M*M -- MG/M*M*M) ON BASE 1 AT 1000

M P	AGENT #1		AGENT #2		AGENT #3	
1	694.39	0.109	0.00	0.000	0.00	0.000
2	0.62	0.101	0.00	0.000	0.00	0.000
3	65.07	0.022	0.00	0.000	0.00	0.000
4	1.26	0.116	0.00	0.000	0.00	0.000
5	65.04	0.004	0.00	0.000	0.00	0.000
6	0.32	0.099	0.00	0.000	0.00	0.000
8	479.57	0.253	0.00	0.000	0.00	0.000
9	0.32	0.015	0.00	0.000	0.00	0.000
10	0.61	0.071	0.00	0.000	0.00	0.000
11	0.00	0.000	0.00	0.000	0.00	0.000
12	0.00	0.001	0.00	0.000	0.00	0.000
13	0.00	0.000	0.00	0.000	0.00	0.000
14	0.00	0.000	0.00	0.000	0.00	0.000
15	0.00	0.000	0.00	0.000	0.00	0.000
16	482.17	0.575	0.00	0.000	0.00	0.000
17	801.76	0.131	0.00	0.000	0.00	0.000
18	0.00	0.000	0.00	0.000	0.00	0.000
19	0.00	0.000	0.00	0.000	0.00	0.000
20	0.00	0.000	0.00	0.000	0.00	0.000
21	460.82	0.289	0.00	0.000	0.00	0.000
22	0.00	0.000	0.00	0.000	0.00	0.000
23	0.00	0.000	0.00	0.000	0.00	0.000
24	689.44	0.068	0.00	0.000	0.00	0.000
25	0.00	0.000	0.00	0.000	0.00	0.000
26	30.68	0.243	0.00	0.000	0.00	0.000
27	689.44	0.059	0.00	0.000	0.00	0.000
28	693.85	0.068	0.00	0.000	0.00	0.000
29	0.00	0.000	0.00	0.000	0.00	0.000
30	0.00	0.000	0.00	0.000	0.00	0.000

```
CURRENT MOPP REQUIREMENTS FOR THE FACILITIES AT BASE # 1
  1   2   3   5   7   9  10  12  27  28  30  31  32  40  41  44  46  48  51  52  62  71 101 102 111
  1   1   1   1   1   1   1   2   1   1   1   1   2   1   1   1   2   2   1   1   1   1   1   2   1
112 121 122 123 124 125 126
  1   1   1   1   1   1   1
CURRENT MOPP REQUIREMENTS IN THE AIRCRAFT SHELTERS
  1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24
  1   1   1   1   1   1   2   2   2   2   1   1   1   1   1   1   2   2   1   1   2   2   2   2
CURRENT MOPP REQUIREMENTS ON THE AIRCRAFT PARKING RAMPS
  1   2
  1   1
CURRENT MOPP REQUIREMENTS ON EACH TAXIWAY
  1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25
  2   2   1   2   1   2   1   2   2   2   1   1   1   2   2   2   1   2   1   1   1   1   1   1   1
 26  27  28  29  30  31  32  33  34  35  36  37  38  39  40  41  42  43  44  45
  1   1   2   2   2   2   1   1   1   1   1   1   1   2   2   1   1   1   2   2
```

Fig. 31—Sample of CW data available as periodic reports

were damaged but one shelter was damaged. The runway is closed, and none of the shelters can access the location selected for the MOS until some taxiways are cleared. There were 25 casualties, with 16 persons hospitalized and 9 killed. Following the attack report are the notices that are printed when RPRINT and APRINT are set to low values. The MOS was opened on Base #2 and the shelters there had all gained access to the MOS at about 1230. The next notices are of equipment losses sustained at Base #1 during UXO clearance. The beginning of repair work on damaged buildings and aircraft shelters is also reported.

Much later (at 2006) the MOS at Base #1 is opened. Then, at midnight, when the civil engineering personnel change shift, three shelter repairs at Base #1 are stopped and restarted; work on the third of these tasks is scheduled to be interrupted at 1200 on day 2.

The other data on Fig. 32 provide a summary of the overall status at the end of day 1. There are 49 aircraft assigned at the airbases even though 7 have been lost (and 11 damaged); only 48 were assigned at the beginning of the simulation. This can happen since fillers are sent to operational bases when aircraft go to the rear maintenance base. Nine of the 18 fillers were sent forward to the operational bases and 7 of the 24 CONUS reserves were started forward to the theater to replace the losses. There are 11 aircraft on Base #1, 10 aircraft on Bases #2 and #3; 13 at Base #4, and 5 at the rear maintenance Base #6. The high number of aircraft at the DOBs could be because pilots were unavailable to ferry aircraft home that needed to return after having been pinned out, or because they were unavailable to return the aircraft to their host for maintenance. During the day, 6 aircraft transferred to Base #3 and 4 to Base #4 in accord with the transfer directives. Others landed at these bases when they were pinned out from their host base; as a result, a total of 15 aircraft transferred from the DOBs to the hosts during the day. Furthermore, 7 aircraft were sent to the rear (Base #6); 2 from Base #1, 3 from Base #3, and 2 from Base #4. Five aircraft were flown forward, all to Base #1. Overall the 4 bases flew 52 sorties on day 1, with 24 of them flown from Base #2.

The end-of-day summary on Figure 32 also lists the sorties at each base by mission and hour, aircraft activities by base and aircraft type, and summaries of the runway and taxiway activities, personnel actions, and work-rest time. For example, of the 48 mission #1 sorties and 48 mission #2 sorties demanded at Base #1, only 3 and 9, respectively, were flown; they were all flown during the 2 hours ending at 0700. Figure 32 also illustrates the daily summary of cumulative runway and taxiway clearance

```
DAY  1 TIME 1215:    BASE # 1 SUSTAINED AN AIR ATTACK.
                  OF  10 ( 10) ON BASE AIRCRAFT  0 ( 0)  WERE DESTROYED AND  0( 0)  WERE DAMAGED.    0/ 1 SHELTERS WERE KILLED/DAMAGED.
DAY  1 TIME 1215 BASE 1:   0 UXO, 185 MINES, AND   2 CRATER REPAIRS ARE REQUIRED FOR RUNWAY #1 (AT  1000 100) MCL,MCW = 2500   50
  0 % OF THE SHELTERS HAVE ACCESS TO THE RUNWAY
  25 PERSONNEL WERE CASUALTIES OF WHICH   16 WERE HOSPITALIZED.          OF   0 LOST AIR CREWS   0 WILL RECOVER.
     MATERIAL LOSSES:   EQUIPMENT   5    SPARE PARTS    0     MUNITIONS    0

                 NUMBERS OF PERSONNEL CASUALTIES BY TYPE

            31   32   63   72   76     191  192  196
             7    4    8    1    1       1    2    1
             3    3    5    1    1       1    1    1
             0    0    0    0    0       0    0    0

MAINTENANCE ACTIVITIES WERE DELAYED UNTIL 1418 AND FACILITY RECONSTRUCTION WAS DELAYED UNTIL 1448 FOR POST-ATTACK CLEAN-UP
CRATER REPAIRS ON THE RUNWAYS AND TAXIWAYS WILL BEGIN AT 1239 AFTER THE ALLOWANCE FOR SURVEY, EOD, AND MINE REMOVAL

 AIR CREWS   36   SURVIVING POL  26990   SPARE PARTS: LRU  161 SRU  210     AIRCRAFT SHELTERS: SURVIVED  24  DAMAGED  4
 CUMULATIVE AIRCRAFT KILLED / DAMAGED DURING AIRBASE ATTACKS    1    1
DAY  1 TIME 1224 BASE 2 RUNWAY 1 CURRENT MOS (OR EXTENDED MOS) CLEARANCE HAS BEEN COMPLETED
DAY  1 TIME 1236        --   100% OF THE  SHELTER SPACES AT BASE # 2 NOW HAVE ACCESS TO THE RUNWAY
   CE EQUIPMENT LOST AT BASE  1 USING PROCEDURE   1 AT   265    TYPE:196   NUMBER LOST 1
   CE EQUIPMENT LOST AT BASE  1 USING PROCEDURE   1 AT   265    TYPE:196   NUMBER LOST 1
FACILITY #  1 ON BASE # 1 SUSTAINED  83.00% DAMAGE.  REPAIR BEGAN ON DAY  1 AT 14.8 HRS
FACILITY # 10 ON BASE # 1 SUSTAINED   9.60% DAMAGE.  REPAIR BEGAN ON DAY  1 AT 14.8 HRS
FACILITY #  7 ON BASE # 1 SUSTAINED   9.00% DAMAGE.  REPAIR BEGAN ON DAY  1 AT 14.8 HRS
 REPAIR OF SHELTER   6 ON BASE # 1 STARTED AT 14.8 HRS ON DAY  1  STEP COMPLETION EXPECTED AT  3.5 HRS ON DAY  2
 REPAIR OF SHELTER  14 ON BASE # 1 STARTED AT 14.8 HRS ON DAY  1  STEP COMPLETION EXPECTED AT  2.4 HRS ON DAY  2


DAY  1 TIME 2006 BASE 1 RUNWAY 1 CURRENT MOS (OR EXTENDED MOS) CLEARANCE HAS BEEN COMPLETED
 REPAIR OF SHELTER   6 ON BASE # 1 STARTED AT  0.0 HRS ON DAY  2  STEP COMPLETION EXPECTED AT  3.5 HRS ON DAY  2
 REPAIR OF SHELTER  14 ON BASE # 1 STARTED AT  0.0 HRS ON DAY  2  STEP COMPLETION EXPECTED AT  2.4 HRS ON DAY  2
 REPAIR OF SHELTER   9 ON BASE # 1 STARTED AT  0.0 HRS ON DAY  2  TO BE STOPPED AT 12.0 HRS ON DAY  2

DAY  1    TRIAL #  1    TOTAL AIRCRAFT:    ASSIGNED  49    LOST   7   DAMAGED  11          RUN ID# 26995   JULY  3, 1989
 AIRCRAFT BY BASE    11         10         10         13         0          5
RESERVES BY TYPE    17
 FILLERS BY TYPE    9
DOB AIRCRAFT FROM HOST (OR TO HOST) BY BASE          4        11        6        4
AIRCRAFT TO REAR / FROM REAR BY BASE            2/  5    0/  0    3/  0    2/  0

    SORTIES:  DAILY TOTAL   52  CUMULATIVE: TOTAL    52      BY BASE:     12    24     9     7     0     0

SORTIES FLOWN      3   9   0   0   0  12  12   0   0   0   9   0   0   0   0   7   0   0   0   0
       DEMANDED   48  48   0   0   0  48  48   0   0   0  24   0   0   0   0  24   0   0   0   0

                                   SORTIES LAUNCHED DURING HOUR ENDING AT:
BASE    1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:0010:0011:0012:00    1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:0010:0011:0012:00
  1       0    0    0    0    0    3    9    0    0    0    0    0       0    0    0    0    0    0    0    0    0    0    0    0
  2       0    0    0    0    0    0   20    0    0    0    0    0       0    0    0    0    0    0    2    2    0    0    0    0
  3       0    0    0    0    0    0    3    1    0    0    0    0       0    3    0    0    0    0    0    2    0    0    0    0
  4       0    0    0    0    0    0    0    0    0    2    2    0       1    1    0    0    0    0    1    0    0    0    0    0

                              DAILY ACTIVITY SUMMARY BY BASE AND AIRCRAFT TYPE
  BASE AC     COMBAT      ATTACK      ABORTS     CANN   CUM               TO   FR/TO  TO/FR        CHECK        SORTIES BY MISSION
          LOST  DAMG  LOST  DAMG   AIR   GND          NMCS               REAR FILLER  DOB          FLTS   #1    #2    #3    #4    #5
  1   1     2     2     1     1     0     0      0     0      0     0     2     8    10     0      0     6    12     0     0     0
  2   1     2     1     0     0     0     0      0     0      0     0     0     3    11     0      1    15    12     0     0     0
  3   1     1     5     0     0     0     0      0     0      0     0     3     0     6     0      0     9     0     0     0     0
  4   1     1     3     0     0     0     0      0     0      0     0     2     0     4     0      0     7     0     0     0     0

                                 COMPLETED RUNWAY AND TAXIWAY REMOVAL OPERATIONS
     BASE # 1     RUNWAYS:   UXO   15   MINES  432   CRATERS    2          TAXIWAYS:  UXO   26   MINES  564   CRATERS   29
     BASE # 2     RUNWAYS:   UXO    8   MINES  523   CRATERS    6          TAXIWAYS:  UXO   40   MINES  490   CRATERS   16

                        PERSONNEL FATALITIES, HOSPITALIZATIONS, AND HEAT EFFECTS

         BASE      PERSONNEL        FATALITIES         HOSPITAL        HEAT    MAN-HRS    ENTER    COOLER    QUEUE      ENROUTE
                INITIAL-FINAL     IMMED-DELAYED     IMMED-DELAYED   COLLAPSE   CLINIC    COOLER   MAN-HRS   DELAYS    PERSONNEL
          1      838     755       18      3         34      18         0      7189       572      149        0          84
          2      838     814        0      2          8       2         0      1747       130       71        0          11
          3      182     190        0      0          0       0         3       102        85       31        0           3
          4      182     195        0      1          0       0         0         0        84       38        0           0
          5       60      60        0      0          0       0         0         0         0        0        0           0
          6       84      89        0      0          0       0         0         0         0        0        0           0

           DAILY WORK-REST TIMES (MIN)                    CUMULATIVE WORK-REST TIMES (MIN)                       TASK INTERRUPTIONS
      ***************************************     ****************************************************       ******************
BASE  FLIGHT         BACK    MUNITIONS   CIVIL        FLIGHT           BACK         MUNITIONS        CIVIL       TOTAL LIMITED  VOGT    VOGT
       LINE          SHOPS   ASSEMBLY  ENGINEERS      LINE             SHOPS        ASSEMBLY       ENGINEERS     TASKS          LIMIT   REST
 1     34    1    147    0   238    4   122  13     34   1( 11)  147   0(  0)  238   4(  6)  122  13( 17)     260     0       0       0
 2     39    1     97    0   284    5   164  39     39   1( 14)   97   0(  0)  284   5( 13)  164  23( 29)     202     1       1       1
 3     71    2    132   24   188   29     0   0     71   2( 10)  132  24( 24)  188  29( 29)    0   0(  0)     154     1       0       2
 4     47    1    286    0   176   34     0   0     47   1(  9)  286   0(  0)  176  34( 34)    0   0(  0)     144     1       0       5
 6     76    0     78    0     0    0     0   0     76   0(  0)   78   0(  0)    0   0(  0)    0   0(  0)      35     0       0       0

                                  NMCS AC BY BASE      0    2    0    1    0    1

                     CUMULATIVE NMCS-HOURS BY BASE      0      3      3      9      0      3
```

Fig. 32—Listing for a conventional attack at Base #1 and other data for day 1

operations and personnel status data. As noted, a total of 8 UXO, 523 mines, and 6 craters were cleared on Base #2 runways, and 40 UXO, 490 mines, and 16 "equivalent" craters on the taxiways. The summaries of personnel activities at the bottom of Fig. 32 are fully explained in connection with Fig. 37.

Figure 33 provides another illustration of the type of listing that TSAR will generate for a day's activities when RPRINT = 2 and APRINT = 3. This is just a small excerpt from the records that can be generated; it has been edited to eliminate most Base #2 activities and most Base #1 taxiway activities. Records are printed at the beginning and end of each step of each runway and taxiway repair. These records specify the base, the start and stop times, the runway or taxiway arc that is being worked on, the kind of job being done (1 = UXO, 2 = mines, 3 = craters), and the type of repair procedure being used,[1] the status[2] of the repair, and the numbers of UXOs, mines, and crater repairs that remain to be initiated, and that are being worked on.[3] The sample in Figure 33 starts at noon on day 1 when three interrupted runway repair tasks were restarted; the first two tasks are the first step of 20-foot crater repairs on arcs #2 and #3 (since KIND = 3 specifies crater repair, and INDEX = 20 × N + Step, where N = 2—i.e., a 20-foot crater—and Step = 1). The third interrupted task was to finish sweeping mines (KIND = 2) on arc #4. Work was also resumed on two facilities and started on two aircraft shelters. Fifteen minutes later Base #1 was attacked again and the three runway tasks were interrupted again. Runway #1 is again selected as the location for the MOS. This listing skips the other attack results and resumes with a mine clearing task[4] being started on arc #2, and two casualty reports—most likely from UXO detonations during repairs on the taxiways. Sweeping is complete on arc #2 at 266 TTU and then started on arc #3

[1]The type of repair procedure is coded as INDEX, where INDEX = 20 × N + Step; Step is the step number of the repair procedure, and N is the weapon type for UXOs, and, for crater repairs, the N*th*-sized crater is specified with the CT37/77 cards. For mines, INDEX denotes a location in the REMINE array.

[2]FCOMP1 denotes the fraction of the repair step that had been completed when the repair started, and FCOMP2 the fraction completed when it stopped or is scheduled to stop. When only FCOMP is listed, FCOMP1 and FCOMP2 follow.

[3]The first three of the six numbers at the right end of the runway records are the numbers of UXO, mines, and craters that remain to be initiated, and the last three are the numbers that are being worked. The three numbers at the right end of the taxiway task records are the numbers of UXO, mines, and craters that have yet to be started on the taxiway arc.

[4]The number of mines to be cleared and the number of the removal procedure are appended at the right end of the report when mine removal is started.

at 269; subsequently sweeping is started on arc #4[5]. Work on the first step of the two partially repaired craters is restarted at 292 TTU. Three facilities and two shelter repairs are then started at 14.8 hours, i.e., 296 TTU. As taxiway arcs are cleared the current access to shelters is noted. There is then a series of crater repair reports as the first repair steps are completed, and the second and third steps are started and then completed, terminating with MOS availability at 402 TTU, or 2006. And by early the next day—0018 on day 2—all shelters have obtained access to the MOS.

Figure 34 illustrates the type of data the user may request using CT2/4 and DPRINT (CT2/5). In this case CT2/4 specifies an aircraft status report at 1900 on day 6 and every 6 days thereafter. DPRINT = 1000 requested a full listing of the available data for all bases; lesser values of DPRINT would limit the output as described in Sec. XIX. Figure 34 shows that at 1900 on day 6 there are 17 aircraft assigned to Base #1; three are in flight, nine are ready to fly, four are undergoing maintenance and have not had final mission assignment, and one has been assigned but has not yet completed maintenance. There are currently no aircraft undergoing deferred maintenance, although seven aircraft have deferred tasks. Individual aircraft "status" is the twelfth element of the ACN array: 1 = *in flight*; 2 = *postflight delay*; 3 = maintenance before assignment; 4 = preflight delay; 5 = maintenance after assignment; 6 = maintenance complete; 7 = deferred maintenance underway. For each aircraft, up to six ongoing and waiting tasks and three interrupted tasks are then listed. (The existence of a larger number of tasks would be shown by an asterisk to the right of each list.) The entry for waiting tasks is negative when the entry is the task number, and positive when the entry is the cause for the wait. In this instance, the only tasks waiting at Base #1 are for aircraft #12, and the load crew that will do those tasks is currently doing task #42. Since the aircraft isn't actually waiting for resources—a load crew is assigned—the negative task numbers are listed. Only three of the aircraft that are ready to fly at Base #1 are listed, to record the fact that parts not needed for their assigned mission have been cannibalized; the number of such parts is listed in the last column. The other ready aircraft are not reported because there is nothing to report. Base #2 has a limited number of Type #12 equipment, and "12012" is reported as the cause for tasks waiting for six aircraft. The delays are defined either by

[5]As will be noted, the number of mines removed from the three arcs—43, 48, and 94—equal the total that needed to be removed for the MOS. Note also that the mine removal task on arc #4 is not treated as an interrupted task when the interruption is the result of a new attack; the entire arc must be swept again after a fresh attack.

```
START RUNWAY CLEARANCE  BASE 1 TTU:  240  281 ARC  2 KIND 3 INDEX 41 FCOMP 18 100 REPAIRS   0    0    0    0    0   1
START RUNWAY CLEARANCE  BASE 1 TTU:  240  275 ARC  3 KIND 3 INDEX 41 FCOMP 20 100 REPAIRS   0    0    0    0    0   1
START RUNWAY CLEARANCE  BASE 1 TTU:  240  248 ARC  4 KIND 2 INDEX  3 FCOMP 31 100 REPAIRS   0    0    0    0    1   0
FACILITY # 10 ON BASE # 1 HAS    2.85% DAMAGE.    REPAIR RESUMED ON DAY  1 AT 12.0 HRS
FACILITY #  9 ON BASE # 1 HAS   14.92% DAMAGE.    REPAIR RESUMED ON DAY  1 AT 12.0 HRS
 REPAIR OF SHELTER   14 ON BASE # 1 STARTED AT 12.0 HRS ON DAY  1  STEP COMPLETION EXPECTED AT 23.8 HRS ON DAY  1
 REPAIR OF SHELTER    6 ON BASE # 1 STARTED AT 12.0 HRS ON DAY  1  TO BE STOPPED AT   0.0 HRS ON DAY  2

DAY  1 TIME 1215:     BASE # 1 SUSTAINED AN AIR ATTACK.
           OF  10 ( 10) ON BASE AIRCRAFT  0 ( 0)  WERE DESTROYED AND  0( 0)  WERE DAMAGED.    0/ 1 SHELTERS WERE KILLED/DAMAGED
  STOP RUNWAY  CLEARANCE BASE 1 TTU:  240  245 ARC  2 KIND 3 INDEX 41 FCOMP 18  28 REPAIRS  0    0    0    0    0   1
  STOP RUNWAY  CLEARANCE BASE 1 TTU:  240  245 ARC  3 KIND 3 INDEX 41 FCOMP 20  31 REPAIRS  0    0    0    0    0   1
  STOP RUNWAY  CLEARANCE BASE 1 TTU:  240  245 ARC  4 KIND 2 INDEX  3 FCOMP 31  74 REPAIRS  0    0    0    0    1   0
                          RUNWAY #1 HAS    0 UXO,  185 MINES, AND   2 CRATERS TO BE CLEARED FOR AN MOS
                          RUNWAY #2 HAS    6 UXO,    0 MINES, AND   5 CRATERS TO BE CLEARED FOR AN MOS
DAY  1 TIME 1215 BASE 1:  0 UXO, 185 MINES, AND   2 CRATER REPAIRS ARE REQUIRED FOR RUNWAY #1 (AT  1000 100) MCL,MCW = 2500   50
 0 % OF THE SHELTERS HAVE ACCESS TO THE RUNWAY
          *****  MOS IS ESTIMATED TO BE AVAILABLE AT BASE # 1 ON DAY  1 AT 1718   *****

START RUNWAY CLEARANCE  BASE 1 TTU:  253  266 ARC  2 KIND 2 INDEX  3 FCOMP  0 100 REPAIRS   (    0    0    0    1   1   MINES  43  2
   CE EQUIPMENT LOST AT BASE  1 USING PROCEDURE    1 AT   265     TYPE:196    NUMBER LOST 1
   CE EQUIPMENT LOST AT BASE  1 USING PROCEDURE    1 AT   265     TYPE:196    NUMBER LOST 1
  STOP RUNWAY  CLEARANCE BASE 1 TTU:  253  266 ARC  2 KIND 2 INDEX  3 FCOMP  0 100 REPAIRS  0    0    0    0    0   1
START RUNWAY CLEARANCE  BASE 1 TTU:  269  280 ARC  3 KIND 2 INDEX  3 FCOMP  0 100 REPAIRS   0    0    0    0    1   1   MINES  48  2
 A TYPE  1 UXO EXPLODED ON BASE # 1 AT   275
     CASUALTIES: 19202      0     0     0     0     0     0     0     EQUIP LOST: 19601     0    0    0    0    0    0    0
 STOP RUNWAY  CLEARANCE BASE 1 TTU:  269  280 ARC  3 KIND 2 INDEX  3 FCOMP  0 100 REPAIRS  0    0    0    0    0   1
START RUNWAY CLEARANCE  BASE 1 TTU:  283  294 ARC  4 KIND 2 INDEX  3 FCOMP  0 100 REPAIRS   0    0    0    0    1   0   MINES  94  2
DAY  1 TIME 1421  ARC # 36 CLEARED AT BASE # 1      --    0% OF THE SHELTERS NOW HAVE ACCESS TO THE RUNWAY
 A TYPE  1 UXO EXPLODED ON ARC #  12 AT BASE # 1 AT    291
START RUNWAY CLEARANCE  BASE 1 TTU:  292  379 ARC  2 KIND 3 INDEX 41 FCOMP 28 100 REPAIRS   0    0    0    0    0   1
START RUNWAY CLEARANCE  BASE 1 TTU:  292  375 ARC  3 KIND 3 INDEX 41 FCOMP 31 100 REPAIRS   0    0    0    0    0   1
 STOP RUNWAY  CLEARANCE BASE 1 TTU:  283  294 ARC  4 KIND 2 INDEX  3 FCOMP  0 100 REPAIRS  0    0    0    0    0   0
FACILITY #  1 ON BASE # 1 SUSTAINED  83.00% DAMAGE.  REPAIR BEGAN ON DAY  1 AT 14.8 HRS
FACILITY # 10 ON BASE # 1 SUSTAINED   9.60% DAMAGE.  REPAIR BEGAN ON DAY  1 AT 14.8 HRS
FACILITY #  7 ON BASE # 1 SUSTAINED   9.00% DAMAGE.  REPAIR BEGAN ON DAY  1 AT 14.8 HRS
 REPAIR OF SHELTER    6 ON BASE # 1 STARTED AT 14.8 HRS ON DAY  1  STEP COMPLETION EXPECTED AT  3.5 HRS ON DAY  2
 REPAIR OF SHELTER   14 ON BASE # 1 STARTED AT 14.8 HRS ON DAY  1  STEP COMPLETION EXPECTED AT  2.4 HRS ON DAY  2
 A TYPE  1 UXO EXPLODED ON ARC #  40 AT BASE # 1 AT    303
 A TYPE  2 UXO EXPLODED ON ARC #  10 AT BASE # 1 AT    304
 A TYPE  1 UXO EXPLODED ON ARC #  12 AT BASE # 1 AT    324
DAY  1 TIME 1627  ARC #  1 CLEARED AT BASE # 1      --    42% OF THE SHELTERS NOW HAVE ACCESS TO THE RUNWAY
DAY  1 TIME 1833  ARC # 44 CLEARED AT BASE # 1      --    42% OF THE SHELTERS NOW HAVE ACCESS TO THE RUNWAY
 STOP RUNWAY  CLEARANCE BASE 1 TTU:  292  375 ARC  3 KIND 3 INDEX 41 FCOMP 31 100 REPAIRS  0    0    0    0    0   1
START RUNWAY CLEARANCE  BASE 1 TTU:  375  392 ARC  3 KIND 3 INDEX 42 FCOMP  0 100 REPAIRS   0    0    0    0    0   1
 STOP RUNWAY  CLEARANCE BASE 1 TTU:  292  379 ARC  2 KIND 3 INDEX 41 FCOMP 28 100 REPAIRS  0    0    0    0    0   1
START RUNWAY CLEARANCE  BASE 1 TTU:  379  396 ARC  2 KIND 3 INDEX 42 FCOMP  0 100 REPAIRS   0    0    0    0    0   1
 STOP RUNWAY  CLEARANCE BASE 1 TTU:  375  392 ARC  3 KIND 3 INDEX 42 FCOMP  0 100 REPAIRS  0    0    0    0    0   1
START RUNWAY CLEARANCE  BASE 1 TTU:  392  398 ARC  3 KIND 3 INDEX 43 FCOMP  0 100 REPAIRS   0    0    0    0    0   1
 STOP RUNWAY  CLEARANCE BASE 1 TTU:  379  396 ARC  2 KIND 3 INDEX 42 FCOMP  0 100 REPAIRS  0    0    0    0    0   1
START RUNWAY CLEARANCE  BASE 1 TTU:  396  402 ARC  2 KIND 3 INDEX 43 FCOMP  0 100 REPAIRS   0    0    0    0    0   1
 STOP RUNWAY  CLEARANCE BASE 1 TTU:  392  398 ARC  3 KIND 3 INDEX 43 FCOMP  0 100 REPAIRS  0    0    0    0    0   0
DAY  1 TIME 1957  ARC #  6 CLEARED AT BASE # 1      --    92% OF THE SHELTERS NOW HAVE ACCESS TO THE RUNWAY
 STOP RUNWAY  CLEARANCE BASE 1 TTU:  396  402 ARC  2 KIND 3 INDEX 43 FCOMP  0 100 REPAIRS  0    0    0    0    0   0
DAY  1 TIME 2006 BASE 1 RUNWAY 1 CURRENT MOS (OR EXTENDED MOS) CLEARANCE HAS BEEN COMPLETED
DAY  1 TIME 2048  ARC # 13 CLEARED AT BASE # 1      --    92% OF THE SHELTERS NOW HAVE ACCESS TO THE RUNWAY
DAY  1 TIME 2257  ARC # 23 CLEARED AT BASE # 1      --    92% OF THE SHELTERS NOW HAVE ACCESS TO THE RUNWAY
FACILITY #  1 ON BASE # 1 HAS   72.30% DAMAGE.    REPAIR RESUMED ON DAY  2 AT   0.0 HRS
FACILITY # 10 ON BASE # 1 HAS    7.87% DAMAGE.    REPAIR RESUMED ON DAY  2 AT   0.0 HRS
FACILITY #  7 ON BASE # 1 HAS    5.82% DAMAGE.    REPAIR RESUMED ON DAY  2 AT   0.0 HRS
 REPAIR OF SHELTER    6 ON BASE # 1 STARTED AT   0.0 HRS ON DAY  2  STEP COMPLETION EXPECTED AT  3.5 HRS ON DAY  2
 REPAIR OF SHELTER   14 ON BASE # 1 STARTED AT   0.0 HRS ON DAY  2  STEP COMPLETION EXPECTED AT  2.4 HRS ON DAY  2
 REPAIR OF SHELTER    9 ON BASE # 1 STARTED AT   0.0 HRS ON DAY  2  TO BE STOPPED AT 12.0 HRS ON DAY  2

DAY  1     TRIAL #  1    TOTAL AIRCRAFT:    ASSIGNED  49     LOST   7     DAMAGED  11           RUN ID# 32415      JULY 27, 1989
 AIRCRAFT BY BASE     11         10         10          13          0          5

   SORTIES:  DAILY TOTAL   52  CUMULATIVE: TOTAL    52       BY BASE:    12    24     9     7     0     0

DAY  2 TIME     6  ARC # 24 CLEARED AT BASE # 1      --  100% OF THE SHELTERS NOW HAVE ACCESS TO THE RUNWAY
```

Fig. 33—Sample listing of runway repair activity with RPRINT = 3

a part number between 1 and 9999, or as [Class × 2000 + 8000 + Type] for other resource shortages. Thus "12012" denotes Class 2 (equipment) and Type #12.

Figure 35 shows the response to the user request (SCROLL on CT2/1) that the activities of aircraft #25 through #36 be printed for the first three days of the simulation; this record is for day 1. The aircraft number is listed at the top. TSAR initialization procedures assigned these numbers to aircraft at Base #2. The next four rows contain (1) the number of sorties flown during the day, (2) the base to which the aircraft is currently (at midnight) assigned and the aircraft type, (3) the aircraft's current status, and (4) the number of parts missing from the aircraft ("holes"). The status is a coded number that indicates whether work is currently ongoing, waiting, and/or interrupted; this "status" is different from that reported in Fig. 34. If the value is zero, the aircraft is ready to fly (or in flight); or if the value is −1, all work has been done, except that mission assignment and the uploading of mission-dependent munitions have been deferred until LOADTM (0215 in this example). Aircraft #25, for example, is waiting for one or more tasks; aircraft #26 has finished maintenance except for loading the final munitions; and aircraft #31 has one (or more) tasks in process, and one interrupted task (since 4 + 1 = 5). Following these initial data, the history of each aircraft during the day is listed. The time each event was first attempted is entered first, followed by the time it was completed; the third entry is either the task number or an alphanumeric indicator for special events. In this sample, all aircraft had an early morning inspection (Task #53) performed, starting at 0345. The first four aircraft were then TRANSferred to Base #4 at 0445. Although aircraft #27 was ready to fly at 1436, it probably was not launched because the aircrews had completed a 12-hour day by 1545 (i.e., 0345 + 1200).

The remainder of the aircraft at Base #2 were launched on combat missions between 0618 and 0645 and recovered an hour later, except aircraft #29, which was lost. Aircraft #31 required maintenance at the rear base and the ferry flight began at 0806. Aircraft #32 flew only one sortie and was still having battle damage repaired at midnight. Only aircraft #36 flew three sorties and remained at Base #2 all day. When aircraft #36 landed after its first sortie it was hot-pit refueled (FUEL) and then underwent the postflight inspection (Task #201) specified for mission #1. Auxiliary fuel tanks were attached and the basic munitions were loaded (Tasks #42, #43, and #44). The aircraft was reconfigured (CONF) and the mission-dependent munitions were loaded (ARM). Work was complete at 1148 and the aircraft was launched on a second combat sortie at

```
                    PERIODIC SUMMARY OF AIRCRAFT STATUS AND TASK DEFERRALS          DAY:   6     TIME: 1900

OF  17 AIRCRAFT ASSIGNED TO BASE # 1,    3 ARE IN FLIGHT
       MAINTENANCE STATE:   NOT YET ASSIGNED:   4 ASSIGNED:   1   COMPLETE:   9   DEFERRED MAINTENANCE:   0
       BY TYPE:       4    1    9    0
         7 AIRCRAFT   ( 41.2%)   AVERAGE  1.2 DEFERRED TASKS;     0  (   0.0%)   AVERAGE   0.0 FROM "CRITICAL SHOPS".
       NUMBER AIRCRAFT ASSIGNED BY MISSION AND TYPE
                 2    8    0    0    0
TAIL NO      12  25  30  11  33     3   6  22  18  35    19  50   1   2  20    24  34
AC TYPE       1   1   1   1   1     1   1   1   1   1     1   1   1   1   1     1   1
 STATUS       3   3   6   6   6     6   6   6   6   1     5   3   1   3   6     6   1
DEF TASKS     0   0   2   0   0     0   1   0   1   1     1   0   1   0   1     0   0
HOLES         0   2   0   0   0     0   0   0   0   0     0   0   0   0   0     0   0

                              STATUS OF INDIVIDUAL AIRCRAFT AT BASE # 1                                                REQD
  AC   STATUS DAMAGE     ONGOING TASKS                                CAUSE FOR WAIT                INTERRUPTED TASKS   PARTSA
  12     3      0          42    0    0    0    0    0 0   -43   -44    0    0    0    0 0    0    0    0 0    0
  25     3      0          17    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    2
  30     6      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    1
  18     6      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    1
  35     1      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
  19     5      0       30027    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    1
  50     3      1         101    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
   1     1      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
   2     3      0          44    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
  20     6      0          44    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    1
  34     1      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0

OF  22 AIRCRAFT ASSIGNED TO BASE # 2,    6 ARE IN FLIGHT
       MAINTENANCE STATE:   NOT YET ASSIGNED:   8 ASSIGNED:   5   COMPLETE:   3   DEFERRED MAINTENANCE:   0
       BY TYPE:       8    5    3    0
         8 AIRCRAFT   ( 36.4%)   AVERAGE  1.0 DEFERRED TASKS;     0  (   0.0%)   AVERAGE   0.0 FROM "CRITICAL SHOPS".
       NUMBER AIRCRAFT ASSIGNED BY MISSION AND TYPE
                 3    5    0    0    0
TAIL NO      45  27  46  48  39    14  15  43   4   7    53  32  44  29  21     5  17  26  49  52    28  41
AC TYPE       1   1   1   1   1     1   1   1   1   1     1   1   1   1   1     1   1   1   1   1     1   1
 STATUS       3   6   3   5   1     5   3   1   1   6     3   3   1   5   6     5   1   3   3   5     1   2
DEF TASKS     0   1   0   0   1     0   0   1   1   1     0   0   1   0   0     1   1   0   0   0     0   0
HOLES         0   0   0   0   0     0   0   0   0   0     0   0   0   0   0     0   0   0   0   0     0   0

                              STATUS OF INDIVIDUAL AIRCRAFT AT BASE # 2                                                REQD
AC #  STATE DAMAGE     ONGOING TASKS                                CAUSE FOR WAIT                INTERRUPTED TASKS    PARTS
  45     3      0           0    0    0    0    0    0 0  12012-30026    0    0    0    0 0    0    0    0 0    0
  46     3      0           6    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    1
  48     5      0           0    0    0    0    0    0 0  12012     0    0    0    0    0 0    0    0    0 0    0
  39     1      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
  14     5      0           0    0    0    0    0    0 0  12012     0    0    0    0    0 0    0    0    0 0    0
  15     3      1         112    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
  43     1      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
   4     1      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    1
   7     6      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    1
  53     3      1           0    0    0    0    0    0 0  12012     0    0    0    0    0 0    0    0    0 0    0
  32     3      0           2    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
  44     1      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
  29     5      0           0    0    0    0    0    0 0  12012     0    0    0    0    0 0    0    0    0 0    0
   5     5      0          18 30027    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    1
  17     1      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    1
  26     3     11         104    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    1
  49     3      0           3    0    0    0    0    0 0 -30026     0    0    0    0    0 0    0    0    0 0    0
  52     5      0           0    0    0    0    0    0 0  12012     0    0    0    0    0 0    0    0    0 0    0
  28     1      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
  41     2      0           0    0    0    0    0    0 0     0     0    0    0    0    0 0    0    0    0 0    0
```

Fig. 34—Sample of aircraft status reports that are available periodically

```
                          DAY    1   DAILY AIRCRAFT ACTIVITIES

   25   26     27   28     29   30     31   32     33   34     35   36
             (SORTIES     BASE/AC TYPE   STATUS     HOLES)

(TASK STATUS = 4 IF ONGOING; +2 IF WAITING; +1 IF INTERRUPTED; -1 IF UPLOADING DEFERRED)

    1    1      1    2      0    1      1    1      3    0      2    3
  4 1  1 1    4 1  2 1    3 1  4 1    6 1  2 1    6 1  1 1    6 1  2 1
    2   -1      0    0      0    0      5    4      6    0      4   -1
    1    0      0    0      0    0      0    0      1    0      0    0

  345  345    345  345    345  345    345  345    345  345    345  345
  409  409    409  409    409  433    433  433    433  433    457  457
   53   53     53   53     53   53     53   53     53   53     53   53

  445  445    445  445    618  618    618  621    621  618    645  645
  545  545    545  545    718  718    718  721    721  721    745  745
 TRA4 TRA4   TRA4 TRA4   LAND LAND   LAND LAND   LAND LAND   LAND LAND

  603  603    603  603      0  736    736  739    739  739    803  803
  636  709    815  742    718  757    806  818    818  818    842  824
 FUEL FUEL   FUEL FUEL   KILL FUEL   FUEL  201    201  201    201 FUEL

 1045 1045    933  933      0  757    806  818    818  818    842  824
 1145 1145   1033 1033   1021  836    906  903    903  903    927  903
 LAND LAND   LAND LAND    NEW  201   TRA6   42     42   42     42  201

 1203    0   1051 1051   1139  836    927  818    818  818    927  903
 1236 1145   1109 1124   1224  921    954  924    912  924    957  948
  201 KILL   FUEL  201     42   42    105   43    105   43   FUEL   42

 1236    0   1109 1124   1139  836    927  818    818  818    927  903
 1327 1339   1157 1151   1245  942   1000  939    924  939   1000 1009
   42  NEW    201   43     43   43   FUEL   44     43   44    ARM   43

 1236 1457   1157 1124   1139  836      0  818    818  939    927  903
 1354 1518   1248 1209   1300  957      0 1003    939 1009   1027 1024
   43   43     42   44     44   44          105     44 FUEL    ARM   44

 1236 1457   1157 1209   1300  957      0    0    939  939   1309 1024
 1412 1533   1315 1242   1330 1030      0    0   1009 1012   1409 1100
   44   44     43 FUEL   FUEL  ARM               FUEL  ARM   LAND CONF

 1412 1533   1157 1315   1300  957      0    0    939  939   1427 1024
 1445 1539   1333 1415   1333 1057      0    0   1015 1039   1457 1130
 FUEL CONF     44 LAND   CONF  ARM                ARM  ARM   FUEL CONF

    0 1533   1333 1433   1300 1400      0    0    939 1309   1457 1130
    0 1542   1412 1451   1354 1500      0    0   1042 1409   1557 1148
      CONF    ARM FUEL   CONF TRA4                ARM LAND   TRA6  ARM

    0 1542   1333 1451   1354 1518      0    0   1309    0   1618 1306
    0 1600   1436 1524   1427 1551      0    0   1409 1409   1651 1406
       ARM    ARM  201    ARM FUEL               LAND KILL   FUEL LAND

    0 1533      0 1524   1354    0      0    0   1427    0   1618 1424
    0 1603      0 1551   1454    0      0    0   1506 1736   1839 1445
      FUEL           43   ARM                     201  NEW    105 FUEL
    0 1918      0 1524   1454    0      0    0   1506 1854      0 1445
    0 2018      0 1609   1554    0      0    0   1551 1915      0 1530
      LAND           44  TRA3                      42   43           42

    0 2036      0    0   1612    0      0    0   1506 1915      0 1445
    0 2057      0  100   1645    0      0    0   1612 1921      0 1551
      FUEL         TRA2  FUEL                      43 CONF           43

    0 2057      0    0      0    0      0    0   1612 1915      0 1551
    0 2142      0    0      0    0      0    0   1642 1924      0 1609
        42                                       FUEL CONF          ARM

    0 2057      0    0      0    0      0    0   1912 1924      0 1915
    0 2203      0    0      0    0      0    0   2012 1942      0 2015
        43                                       LAND  ARM         LAND

    0 2057      0    0      0    0      0    0   2030 1915      0 2033
    0 2218      0    0      0    0      0    0   2100 1945      0 2054
        44                                       FUEL FUEL           43

    0    0      0    0      0    0      0    0   2100 1915      0 2033
    0    0      0    0      0    0      0    0   2200 1954      0 2109
                                                 TRA6   31           44

    0    0      0    0      0    0      0    0   2221 2000      0 2109
    0    0      0    0      0    0      0    0   2248 2030      0 2139
                                                  105   12         FUEL

    0    0      0    0      0    0      0    0   2221    0      0    0
    0    0      0    0      0    0      0    0   2254    0      0    0
                                                 FUEL

    0    0      0    0      0    0      0    0   2221    0      0    0
    0    0      0    0      0    0      0    0   2333    0      0    0
                                                   17

    0    0      0    0      0    0      0    0   2221    0      0    0
    0    0      0    0      0    0      0    0   2354    0      0    0
                                                   15

    0    0      0    0      0    0      0    0      0    0      0    0
    0    0      0    0      0    0      0    0      0    0      0    0
```

Fig. 35—Output with SCROLL option: First 12 aircraft at Base #2

1306. Note that for aircraft #34 "the number of sorties flown during the day" that is listed at the top is zero, even though the aircraft that initially had this number had flown two sorties before being lost; the data at the top of each column applies to the aircraft in place at midnight.

Figure 36 illustrates the output that is available at day's end when PRINT = 4. Summary data are presented first; 49 aircraft have been lost and 90 damaged during the 12-day period of Trial #2; 41 aircraft remain in the theater, 19 on Base #1, 19 on Base #2, and 3 on the rear maintenance base. A total of 34 airframes were withdrawn to the rear maintenance base during the 12 days, and 41 were sent forward. There were 816 sorties flown, with over 300 from each MOB and more than 50 from each DOB. The sorties are next broken down by mission and base; because the program is dimensioned for five missions per aircraft type, five columns are listed for each base. For example, 42 percent of the mission #1 demands and 35 percent of mission #2 demands were met at Base #1, and 42 percent of both demands were met at Base #2. Figure 36 next shows a cumulative record of the percent of aircraft that had all required maintenance complete within each 30-minute interval from the time that they landed, excluding any mission-dependent munitions tasks that were intentionally delayed until new sortie demand data became available. Aircraft eventually completed maintenance 96.9 percent of the time at Base #1, but only 89.1 percent were completed within 24 hours; 72.1 percent and 83.2 percent completed maintenance in 6 and 12 hours, respectively. The next record indicates how many sorties were flown at each airbase at different times during the twelfth day; in this instance 11 were launched between 0601 and 0700 at Base #1, 5 between 0901 and 1000, etc.

Activities at each base are listed next. The first line summarizes aircraft and flight surface status; a zero for "RUNWAY" denotes that at least an MOS is available, and a one denotes that aircraft may not take off or land; "ACCESS" denotes the percent of the aircraft shelters that may access the MOS. The activities at the several shops on Base #1 for day 12 are shown next on Fig. 36; the same data for the other bases are presented in the complete record. The numbers of on-equipment tasks, parts repairs, and equipment repairs completed during day 12 are listed in the first set of data; Shops #1, #2, and #3 on Base #1 completed 24, 3, and 4 on-equipment tasks, respectively, on day 12. Ninety-two tasks were completed in Shop #25, the shop that conducts basic munitions and fuel tank loading, and postflight inspections. This section of output also lists the cumulative

```
DAY 12    TRIAL # 2    TOTAL AIRCRAFT:    ASSIGNED  41    LOST  49    DAMAGED  90         RUN ID# 26995    JULY  3, 1989
 AIRCRAFT BY BASE     19   .   19        0         0          0        3
DOB AIRCRAFT FROM HOST (OR TO HOST) BY BASE          32         19         30        20
AIRCRAFT TO REAR / FROM REAR BY BASE           13/ 20   11/ 21    7/  0    3/  0

   SORTIES:  DAILY TOTAL    77  CUMULATIVE: TOTAL   816      BY BASE:     370   335    54    57      0     0
FLIGHTS LAUNCHED   7   6   0   0   0   8   7   0   0   0   0   0   0   0   0   0   0   0   0   0
        DEMANDED  16  16   0   0   0  16  16   0   0   0   0   0   0   0   0   0   0   0   0   0

  EFFECTIVENESS   22  17   0   0   0  22  20   0   0   0   0   0   0   0   0   0   0   0   0   0

SORTIES FLOWN     20  17   0   0   0  20  20   0   0   0   0   0   0   0   0   0   0   0   0   0
        DEMANDED  48  48   0   0   0  48  48   0   0   0   0   0   0   0   0   0   0   0   0   0
          FRAC   .42 .35 .00 .00 .00 .42 .42 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00 .00

                         CUMULATIVE DISTRIBUTION OF AIRCRAFT MAINTENANCE TIMES
                          (IN TENTHS OF PERCENT FOR 48 HALF-HOUR PERIODS)

                                            BASE # 1                 ( 0.969)
   0   31    93  222   318  442   556  612   641  674   711  721   736  752   765  775   791  801   811  819   819  824   832  832
 832  832   837  840   840  840   842  848   850  858   860  860   860  863   863  868   868  876   881  881   884  886   891  891

                                            BASE # 3                 ( 0.963)
   0   12    12  309   481  605   704  815   877  889   926  938   963  963   963  963   963  963   963  963   963  963   963  963
 963  963   963  963   963  963   963  963   963  963   963  963   963  963   963  963   963  963   963  963   963  963   963  963

                                       SORTIES LAUNCHED DURING HOUR ENDING AT:
BASE   1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:0010:0011:0012:00    1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:0010:0011:0012:00
 1       0    0    0    0    0    0   11    0    0    5    0    0       0    6    3    0    0    0    0   12    0    0    0    0
 2       0    0    0    0    0    9    2    0    0    5    0    0       6    7    0    0    0    0    6    5    0    0    0    0
 3       0    0    0    0    0    0    0    0    0    0    0    0       0    0    0    0    0    0    0    0    0    0    0    0
 4       0    0    0    0    0    0    0    0    0    0    0    0       0    0    0    0    0    0    0    0    0    0    0    0

                       BASE  1    AIRCRAFT  19      BATTLE DAMAGED:  CURRENT 1    TOTAL 55         (RUNWAY 0;  100% ACCESS)
  SHOP NO          1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24   25
  ON-EQUIP        24   3   4   0   4   0   2   0   1   6   0   9   0   0   0   0   0   0   0   0   0   0   0   0   25
MAN HOURS(X10)    99  17  22   0  14   0  15   0   5  35   0   0   0   0   0   0   0   0   0   0   0   0   0   0   92
  OFF-EQUIP        0   8   2   0   0   0   3   0   0  11   0  15   0   0   0   0   0   0   0   0   0   0   0   0    0  13 121  32   0
MAN HOURS(X10)     0   9  17   0   8   0  10   0   1  46   0  27   0   0   0   0   0   0   0   0   0   0   0   0    0
AGE REPAIR         3   2   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0   0   0   0 409
MAN HOURS(X10)    12   0   1   0   0   0   0   0   0   1   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                                                                                                                   0   0   0   0   0
      SHOP         1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24   25  27  28  29  30
TASKS              1   2   1   0   0   0   0   0   1   3   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0   0   0   0
REPAIRS            0   3   0   0   1   0   0   0   0   2   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0               4
TASKS WAITING      0   0   0   0   0   0   6   0   0   0   0   2   0   0   0   0   0   0   0   0   0   0   0   0    0   0   0   0   0
TASKS INTER        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0
REPAIRS WAIT       0   0   0   0   0   0   0   0   0   9   0   4   0   0   0   0   0   0   0   0   0   0   0   0    0
REPAIRS INTER      0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0    0

                              DAILY ACTIVITY SUMMARY BY BASE AND AIRCRAFT TYPE
BASE AC     COMBAT      ATTACK      ABORTS    CANN   CUM                 TO  FR/TO  TO/FR        CHECK      SORTIES BY MISSION
          LOST  DANG  LOST  DANG   AIR  GND          NMCS               REAR FILLER  DOB          FLTS  #1    #2    #3    #4    #5
 1   1     2     1     0     0      0    0      5     0     0     0      1     2     0     0      6   20    17     0     0     0
 2   1     2     2     0     0      0    0      1     0     0     0      0     0     0     0      4   20    20     0     0     0

                               COMPLETED RUNWAY AND TAXIWAY REMOVAL OPERATIONS
   BASE # 1     RUNWAYS:   UXO    3   MINES  561   CRATERS    3            TAXIWAYS:   UXO   51   MINES  556   CRATERS   32

   BASE # 2     RUNWAYS:   UXO   15   MINES    0   CRATERS   14            TAXIWAYS:   UXO   48   MINES 1372   CRATERS   40

                               NMCS AC BY BASE      8     7     0     0     0     2

           CUMULATIVE NMCS-HOURS BY BASE    1374     564     12     144      0     690

                       STORAGE STATUS
TASKQ  REPQ  WAIT   INTER   RQD   DEF   NORQ  FLTS  ATC   LIMBO BUILD BCKLG  CBJOB  SHIP SHIPQ  RESUP CHANGE SPLITS  COOLER BUDDY
  17     6    41       1    54     8     27    64   20      25     8     0      0    44    45    342     0     54       0     0
   0     0     0       0     0     0      0     0    0       0     0     0      0     0     0      0     0      0       0     0


            SERVICEABLE PARTS                     REPARABLE PARTS             EXPEDITED    CANNIBALIZATIONS    CONDEMNED
                                                                               REPAIRS       LRU    SRU          PARTS
BASE     SHIPPED   FROM     FROM     FROM        TO       TO     TO
                 OPS-BASE   HDQ     CONUS     OPS-BASE   HDQ   CONUS

  1        67       11        6        0         16        0    175            58          16      2           58
  2        70       13        2        0         18        0    129            21          18      0           35
  3         0        1        0        0          1        0      0             0           0      0            0
  4         2        6        0        0          9        0      0             0           3      0            0
  5         0        0        0        0          0        0      0             0           0      0            0
  6         8       97        5        0         13        0     13             0           1      0           24
 10        34        0        0      163          0        0      0             0           0      0            0
          CUMULATIVE FRACTION OF THE AIRCRAFT THAT REQUIRE UNSCHEDULED MAINTENANCE
ALL CAUSES EXCEPT GROUND ABORT   0.592   0.597   0.262   0.247

      CODE2                      0.299   0.295   0.190   0.123
      CODE3                      0.232   0.262   0.071   0.123
      CODE4  (ABDR)              0.119   0.085   0.012   0.000
```

Fig. 36—Typical listing at day's end with PRINT = 4

manhours (divided by 10) that were worked throughout the trial by personnel assigned to the various shops;[6] Shop #1 personnel have worked on on-equipment tasks for 990 manhours, and Shop #28 (munitions) personnel have worked a total of 1210 manhours.

[6]The last four columns are for Shops #27 through #30; there are never any task data to be reported for Shop #26.

Backshop and AGE repair completions and manhours are presented in the same manner. Munitions assembly tasks are reported as backshop work in Shop #30; 4090 manhours have been spent assembling munitions during the 12 days at Base #1.

The second set of shop data present the status of activities in the shops at midnight. One on-equipment task is under way at Shop #1, two at Shop #2, etc. One repair is underway at Shop #5 and two at Shop #10. A negative entry for "REPAIRS" is (minus) the percent damage sustained during air attacks. A damaged shop cannot do backshop repair work, so no activities will be underway at those shops, and no ambiguity occurs as long as the damage is flagged with a minus sign. Although several shops were initially damaged in this problem, all apparently have been repaired since there are no negative entries. (That conclusion cannot be drawn for distributed shops. A negative entry may not be used for a distributed shop to reflect damage, because the "repairs" data element must be reserved for work that may be ongoing at undamaged components of a distributed shop.)

The daily activity summary by base and aircraft type is noted next; on day 12, Bases #1 and #2 each lost two aircraft in combat, and they had 1 and 2 damaged, respectively. Base #1 had five parts cannibalized and six check flights. The cumulative runway/taxiway activities are summarized next, followed by the current number of NMCS aircraft on each base, and the cumulative number of NMCS-hours at each base.

The number of entries in each of the dynamic queues is listed next when PRINT is as great as 4; these data indicate how many columns of these arrays were in use at midnight. The day's report in Fig. 36 is concluded with a record of the cumulative activities affecting aircraft spare parts. The shipments of serviceable and reparable spare parts by base and by destination are presented at the left; and a record of expedited repairs, cannibalizations, and condemnations is shown at the right. Base #2 shipped 70 serviceables and received 13 serviceables from an operational base and 2 from the theater supply base; it also NRTSed 129 reparables to CONUS and 18 to other operational bases; 21 repairs at Base #2 were expedited, 18 parts were cannibalized, and 35 spare parts were condemned. The last entries on Fig. 36 indicate that 59.2 percent of the aircraft that landed at Base #1 and 59.7 percent of the aircraft that landed at Base #2 needed unscheduled maintenance, whereas only about 25 percent of the aircraft that landed at a DOB required such maintenance. The key reason, of course, for this lower

number at the DOBs is that the aircrew often noted that the maintenance was required and recovered at their host base (an MOB) rather than at the DOB from which they had launched.

END-OF-TRIAL OUTPUT STATISTICS

The data presented at the end of a trial are shown in Fig. 37. Forty-one aircraft survived in the theater, 335 of the 1008 flight demands were met, and 816 of the 2784 sorties that were demanded were flown (29.3 percent). A breakdown of sorties by base, mission, and priority is given; the format is the same as in Fig. 36. The summary shop activity data for each base are headed by the number of aircraft currently on base, the current and total numbers of aircraft that have sustained damage, and a status report on runway availability and shelter access. The cumulative numbers of on-equipment tasks, parts repairs, and equipment repairs by shop during the trial are given next.

The next data in Fig. 37 summarize personnel activities during the trial (these same data are also available daily if desired—see DOUTIL on CT2/5). They include the airbase (col. 1); the initial numbers of people on the base (including air crews) (col. 2); the final number on base (col. 3); and the numbers of attack casualities (cols. 4–7) and heat prostration victims (col. 8). The casualties are differentiated between those that occur immediately at the time of an attack and those that are sustained at other times, and between fatalities and hospitalizations. Aircrews that are lost in combat are reported as "delayed fatalities" to keep these personnel tallies complete. Delayed hospitalizations include personnel that suffer chemical effects at the work place, and civil engineering personnel at risk doing runway clearance. The total number of manhours for hospitalization of the victims of heat prostration and airbase attacks (measured only during the simulation) are also listed (col. 9). These data also include the numbers of personnel that had to stop work and cool off (col. 10), and the total number of manhours involved in cooling off (col. 11). When collective-protection queues are simulated, the additional manhours expended in the queues is listed (col. 12); the last entry (col. 13) is the number of personnel that are currently expected to return from the hospital for work at the base (if the simulation continued long enough).

Following the aircraft hours lost for NMCS at each base, a record is printed that summarizes the work-rest times at each base (this record is provided only when USECW > 0, and is available daily if desired). The data include the average length of time

```
                 FINAL RESULTS   TRIAL # 2             SURVIVING AIRCRAFT   41                       RUN ID# 26995   JULY 3, 1989

  335 FLIGHTS FLOWN  74  65   0   0   0  84  62   0   0   0  34   0   0   0   0  36   0   0   0   0
 1008      REQUIRED 192 192   0   0   0 192 192   0   0   0 120   0   0   0   0 120   0   0   0   0

  858 EFFECTIVENESS 216 172   0   0   0 187 163   0   0   0  58   0   0   0   0  62   0   0   0   0

  816 SORTIES FLOWN 198 172   0   0   0 172 163   0   0   0  54   0   0   0   0  57   0   0   0   0
 2784      REQUIRED 576 576   0   0   0 576 576   0   0   0 240   0   0   0   0 240   0   0   0   0
0.293          FRAC .34 .30 .00 .00 .00 .30 .28 .00 .00 .00 .22 .00 .00 .00 .00 .24 .00 .00 .00 .00

                  SORTIE STATISTICS FOR PRIORITY # 1
  445   FLOWN       111  81   0   0   0  91  96   0   0   0  29   0   0   0   0  37   0   0   0   0
 1392   DEMANDED    288 288   0   0   0 288 288   0   0   0 120   0   0   0   0 120   0   0   0   0
 0.32     FRAC      .39 .28 .00 .00 .00 .32 .33 .00 .00 .00 .24 .00 .00 .00 .00 .31 .00 .00 .00 .00

                  SORTIE STATISTICS FOR PRIORITY # 3
  371   FLOWN        87  91   0   0   0  81  67   0   0   0  25   0   0   0   0  20   0   0   0   0
 1392   DEMANDED    288 288   0   0   0 288 288   0   0   0 120   0   0   0   0 120   0   0   0   0
 0.27     FRAC      .30 .32 .00 .00 .00 .28 .23 .00 .00 .00 .21 .00 .00 .00 .00 .17 .00 .00 .00 .00
                        BASE  1     AIRCRAFT  19       BATTLE DAMAGED:  CURRENT 1     TOTAL 55          (RUNWAY 0;  100% ACCESS)
  SHOP NO         1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24     25
 ON-EQUIP       391  36  44   0  38   0  28   0  12  73   0  67   0   0   0   0   0   0   0   0   0   0   0   0    967
 OFF-EQUIP        0  43  68   0  12   0  23   0   3  78   0  99   0   0   0   0   0   0   0   0   0   0   0   0      0
AGE REPAIR       22   5   3   0   1   0   0   0   0   3   0   0   0   0   0   0   0   0   0   0   0   0   0   0
                        BASE  2     AIRCRAFT  19       BATTLE DAMAGED:  CURRENT 2     TOTAL 34          (RUNWAY 0;  100% ACCESS)
  SHOP NO         1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24     25
 ON-EQUIP       361  27  53   0  40   0  29   0  19  51   0  52   0   0   0   0   0   0   0   0   0   0   0   0    931
 OFF-EQUIP        0  39  50   0   9   0   8   0   5  62   0  89   0   0   0   0   0   0   0   0   0   0   0   0      0
AGE REPAIR       12  11   8   0   8   0   4   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

                        PERSONNEL FATALITIES, HOSPITALIZATIONS, AND HEAT EFFECTS

       BASE     PERSONNEL       FATALITIES       HOSPITAL       HEAT     MAN-HRS     ENTER    COOLER    QUEUE     ENROUTE
             INITIAL-FINAL    IMMED-DELAYED    IMMED-DELAYED   COLLAPSE   CLINIC     COOLER   MAN-HRS   DELAYS   PERSONNEL
        1      838    855       15      9        24     16          8     6964       1395      358        0          3
        2      838    830       19      9        56     24         21    14517       1712      557        0         16
        3      182    182        0      2         0      0          0        0        477      162        0          0
        4      182    185        0      2         0      0          0        0        497      166        0          0
        5       60     60        0      0         0      0          0        0          0        0        0          0
        6       84     87        0      0         0      0          0        0         34       13        0          0

          CUMULATIVE NMCS-HOURS BY BASE    1398     585     12     144       0     696

        DAILY WORK-REST TIMES (MIN)                           CUMULATIVE WORK-REST TIMES (MIN)                          TASK INTERRUPTIONS
   ***************************************       *****************************************************************  ******************
BASE  FLIGHT      BACK    MUNITIONS    CIVIL          FLIGHT            BACK          MUNITIONS        CIVIL       TOTAL LIMITED  VOOT   VOOT
       LINE       SHOPS   ASSEMBLY  ENGINEERS          LINE             SHOPS         ASSEMBLY       ENGINEERS     TASKU          LIMIT  REST
 1    44   0   155   3   186  10    0   0        55    1( 15)   165    3( 18)   185    9( 15)   323  10( 14)    5168      7      6      6
 #   400 217    53  44    59  52    0   0      40752381   91    455 358   87   428 354 214     194 109  76
 2    44   0   152   2   146   8    0   6        46    1( 14)   159    3( 22)   184   12( 21)   261  14( 17)    4505     28     24     23
 #   404 213    43  37    40  28    0   1      34562121   93    371 298   41   361 295 177     300 187 161

             FRACTION SORTIES OF AIRCRAFT TYPE  1 THAT LAND WITH N UNSCHEDULED ON-EQUIPMENT BREAKS
                          1      2      3      4      5      6      7      8      9    >=10         TOTAL     TASKS/SORTIE
        DEFERABLE    0.3505 0.0735 0.0061 0.0012 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000         0.4314
        IMMEDIATE    0.2635 0.0245 0.0012 0.0012 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000         0.2904
         EITHER      0.4436 0.1434 0.0306 0.0049 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000         0.6225        0.842

                                      END OF TRIAL SUMMARY OF AIRCRAFT ACTIVITIES

BASE AC    COMBAT      ATTACK      ABORTS     CANN   CUM             TO   FR/TO  TO/FR       CHECK        SORTIES BY MISSION
         LOST DAMG   LOST DAMG    AIR  GND           NMCS           REAR FILLER   DOB        FLTS   #1    #2    #3    #4    #5
 1   1    20   55      2    7      1    0     16     45     0    0    13    35    38     0    55   198   172    0     0     0
 2   1    16   34      4    5      0    0     18      0     0    0    11    34    28     0    35   172   163    0     0     0
 3   1     2    1      0    0      0    0      0      0     0    0     7     0    30     0     0    54     0    0     0     0
 4   1     5    0      0    0      0    0      3     36     0    0     3     0    20     0     2    57     0    0     0     0
 6   1     0    0      0    0      0    0      1      0     0    0     0    10     0     0     0     0     0    0     0     0

                                COMPLETED RUNWAY AND TAXIWAY REMOVAL OPERATIONS
     BASE # 1      RUNWAYS:   UXO    3   MINES  561   CRATERS    3         TAXIWAYS:   UXO   51   MINES  556   CRATERS   32
     BASE # 2      RUNWAYS:   UXO   15   MINES    0   CRATERS   14         TAXIWAYS:   UXO   48   MINES 1372   CRATERS   40

                                 ALL STORAGE QUEUES WERE ADEQUATE FOR TRIAL  2
```

Fig. 37—Partial listing of the final results for Trial #2

personnel worked and have had to rest for each of the four generic task types. The data are presented for the preceding 24 hours and cumulatively for the trial. In each case the results list the average number of minutes that were worked and the average length of any required rest. For the cumulative data, the average rest is presented for all tasks; and, in parentheses, the total rest time is averaged over just those cases where rest was actually required. The results include (1) the total numbers of work team starts, (2) the numbers of tasks that had to be interrupted because of heat considerations, (3) the numbers of interruptions that were based on the Vogt constraints, and (4) the number of rest periods whose duration was based on Vogt criteria.

In this instance, munitions assembly tasks averaged 184 minutes at Base #2; 12 minutes were required, on the average, to cool off after these tasks, or 21 minutes when averaged over those instances when cooling was actually required. When CPRINT > 5, the sample size used to compute these average times is printed on the next line. In this instance work teams commenced munitions assembly jobs a total of 361 times; the average rest time was based on the 295 occasions when the jobs were not stopped by a shift change, or were of such short duration that there was no temperature rise. Of these 295 cases, the work teams had to cool off on 177 occasions before they could be reassigned; in the other 118 cases no rest was required. Overall, 4505 tasks were started on Base #2, and 28 of them had to be interrupted before they were completed; in most instances the interruptions were due to the thresholds imposed by the Vogt constraints.

The next records shown in Fig. 36 are statistics for each aircraft type that indicate the fraction of sorties that landed with N unscheduled maintenance tasks and the average number of unscheduled maintenance tasks per sortie. The data are followed by a record of aircraft activities for the entire trial, differentiated by base and aircraft type, and by a summary of the runway and taxiway activities for the trial.

Figure 38 illustrates the summary of personnel availability and utilization that can be obtained periodically, and at the end of each trial as shown here, when DOUTIL on CT2/5 is initialized. The upper part of this figure indicates the percent of the on-duty personnel that were available; i.e., not assigned, at each odd hour during the day. These data are averaged over the 12 days of the trial and are based on the numbers of personnel on each shift at the beginning of the simulation, to avoid ambiguity when personnel are gained or lost. Data for personnel with a common AFSC that work on the flight line, such as Types #1 and #21, or Types #2 and #22, are combined and reported as Types #1

and #2, respectively. However, the backshop personnel with the same AFSCs are reported separately; Type #72, for example, has the same AFSC as Type #2. In the simulation, Type #78 personnel apparently was rarely used at Base #1, while Types #32 and #77 apparently were the busiest AFSCs. However, personnel casualties also lower availability—as reported here—so that these data are ambiguous when there is an airbase attack, or other changes in base personnel occur during the simulation. The 100+ percent availability for the Type #31 personnel is due to the additional personnel that were received from CONUS after the beginning of the simulation. The cumulative man-hours expended by each personnel type during the trial is shown at the bottom of Fig. 38. In this example we see that the munitions assembly personnel (#64 and #65) and one of the civil engineering personnel (#194) contributed a large fraction of the total manhours.

At the end of a trial all on-equipment and off-equipment jobs that are waiting or have been interrupted are checked, and the final delay statistics (Fig. 41) assume that the delays for waiting tasks are terminated at the end of the trial. Figure 39 presents the record of the waiting and interrupted jobs that is generated when the jobs are checked at the end of the trial; because this record is printed only when PRINT = 8, it will generally be necessary to reset PRINT at the last hour of the trial using a CT49 card to prevent unwanted output from the earlier part of the trial. For on-equipment tasks that are waiting, these records list (1) the base, (2) the resource class that caused the delay, (3) the type of resource, (4) the number of the task, (5) the task status, (6) when the delay began, and (7) the number of the aircraft involved. In this instance the first six records indicate that six aircraft at Base #1 are waiting for part #6; aircraft #20 began waiting at 4795 TTU (near the end of the tenth day), and aircraft #37 has been waiting since 4315 TTU. Back-shop repairs that have been waiting sometimes are distinguished by having 64 added to the base number. The first three parts waiting repair at Base #1 are Type #114 SRUs; the next part repair (Type #10) has been waiting for a Type #77 person for five hours (100 TTU). Similar data are presented when interrupted work is terminated, as will be noted for repair procedure #3 at Base #2.

Figure 40 presents some of the other data that are printed at the end of a trial and whenever task statistics are listed (i.e., every STATFQ days). The data shown here are only for Base #1; the same data are listed for all bases. These statistics are presented for each shop that has had any on-equipment or off-equipment activity. The "standard time" is an estimate generated during initialization of the average task time, in the absence of

CUMULATIVE AVERAGE PERSONNEL AVAILABILITY AS A PERCENTAGE OF THE ORIGINAL SHIFT SIZE
****

PERSONNEL TYPES AT BASE # 1

TIME	1	2	72	3	73	4	74	5	75	6	7	77	8	78	31	32	63	64	65	76
01:00	87	87	65	59	0	70	46	83	96	80	73	25	60	90	129	53	73	67	90	75
03:00	84	90	69	79	0	62	50	79	83	45	78	21	64	92	128	58	73	73	89	75
05:00	66	92	77	83	0	74	62	85	83	78	79	25	73	90	129	58	73	76	85	75
07:00	90	92	73	86	0	75	71	90	96	83	78	21	76	94	130	58	65	79	91	75
09:00	90	89	85	89	73	88	50	98	100	45	90	31	83	98	132	37	75	75	76	47
11:00	88	92	82	97	87	92	33	100	96	72	90	47	90	96	132	44	76	59	86	58
13:00	93	94	82	99	85	91	37	100	100	70	89	36	87	87	126	29	70	72	87	61
15:00	87	82	76	93	81	93	42	100	100	55	90	36	95	79	120	21	68	56	87	61
17:00	93	94	69	97	67	92	29	100	100	48	89	28	95	71	122	25	67	59	72	61
19:00	95	95	74	99	79	94	67	98	100	76	87	36	94	77	127	31	68	74	79	56
21:00	75	70	62	61	0	67	79	71	96	51	79	17	68	96	132	49	66	70	73	92
23:00	85	85	62	34	0	53	54	56	96	71	60	21	43	98	133	44	68	71	77	58

TIME	191	192	193	194	196
01:00	79	92	50	21	92
03:00	91	97	51	21	92
05:00	91	97	52	23	92
07:00	91	97	50	24	92
09:00	85	88	45	31	83
11:00	76	90	47	25	75
13:00	81	90	43	31	64
15:00	82	93	43	21	64
17:00	82	93	43	21	64
19:00	82	91	43	21	64
21:00	82	91	43	21	67
23:00	82	91	44	21	67

CUMULATIVE AVERAGE MANHOURS PER TRIAL FOR EACH TYPE OF PERSONNEL AT BASE 1

TYPE	1	2	72	3	73	4	74	5	75	6	7	77	8	78	31
HOURS	838	226	138	276	117	158	279	162	26	1445	67	317	290	150	303

TYPE	32	63	64	65	76	191	192	193	194	196
HOURS	220	123	3686	2089	176	640	306	238	3958	17

Fig. 38—Personnel availability and utilization records

```
TERMINATE WAIT       1     3     6   TASK       14      STATUS       2      BEGAN   4795    AC # 20
TERMINATE WAIT       1     3     6   TASK       14      STATUS       2      BEGAN   4315    AC # 37
TERMINATE WAIT       1     3     6   TASK       14      STATUS       2      BEGAN   5755    AC # 17
TERMINATE WAIT       1     3     6   TASK       14      STATUS       2      BEGAN   5755    AC #  5
TERMINATE WAIT       1     3     6   TASK       14      STATUS       2      BEGAN   5293    AC # 15
TERMINATE WAIT       1     3     6   TASK       14      STATUS       2      BEGAN   5260    AC #  4
TERMINATE WAIT  1      3   114 REPAIR     114    STATUS     0     BEGAN   1220
TERMINATE WAIT  1      3   114 REPAIR     114    STATUS     0     BEGAN   1340
TERMINATE WAIT  1      3   114 REPAIR     114    STATUS     0     BEGAN   1820
TERMINATE WAIT 65      1    77 REPAIR      10    STATUS     0     BEGAN   5660
TERMINATE WAIT       1     3    20   TASK       35      STATUS       2      BEGAN   5498    AC #  7
TERMINATE WAIT       1     3    20   TASK       35      STATUS       2      BEGAN   5503    AC # 18
TERMINATE WAIT  1      3   141 REPAIR     141    STATUS     0     BEGAN   5735
TERMINATE WAIT 65      1    74 REPAIR     142    STATUS     0     BEGAN   5709
TERMINATE WAIT  1      3   141 REPAIR     141    STATUS     0     BEGAN   5352
TERMINATE WAIT  1      3   141 REPAIR     141    STATUS     0     BEGAN   4749
TERMINATE WAIT       2     1     3   TASK        2      STATUS       1      BEGAN   5720    AC # 25
TERMINATE WAIT  2      3   102 REPAIR     102    STATUS     0     BEGAN   5140
TERMINATE WAIT 66      2     3 REPAIR      -3    STATUS     0     BEGAN   5140
TERMINATE WAIT 66      1    73 REPAIR      -3    STATUS     0     BEGAN   5620
END INTERRUPTED WORK  66       PROCEDURE     3      STATUS       0      BEGAN   4775
TERMINATE WAIT       2     3    20   TASK       35      STATUS       2      BEGAN   5582    AC # 26
TERMINATE WAIT       2     3    20   TASK       35      STATUS       2      BEGAN   5595    AC # 47
TERMINATE WAIT       2     3    20   TASK       35      STATUS       2      BEGAN   5352    AC # 12
TERMINATE WAIT       2     3    20   TASK       35      STATUS       2      BEGAN   5031    AC # 38
TERMINATE WAIT       2     3    20   TASK       35      STATUS       5      BEGAN   5152    AC # 21
TERMINATE WAIT       2     3    20   TASK       35      STATUS       5      BEGAN   5510    AC # 29
TERMINATE WAIT       2     3    20   TASK       35      STATUS       2      BEGAN   5011    AC # 54
TERMINATE WAIT       6     3   203   TASK      103      STATUS       2      BEGAN   4177    AC # 48
TERMINATE WAIT       6     3   203   TASK      103      STATUS       2      BEGAN   4651    AC # 24
TERMINATE WAIT 70      2    31 REPAIR    -144    STATUS     0     BEGAN   4235
```

Fig. 39—Special listing of waiting and interrupted tasks
at end of trial when PRINT = 8

any delays due to resource shortages or slowdowns due to chemical ensembles. These data also include a record of the numbers of LRUs and SRUs that have been processed by each AIS station; in this instance 27 LRUs were processed at station #1, 23 at station #2, and 34 at station #3. A record of the surviving resources is also listed with these results if there have been any attacks on the airbase, or if the program has been directed to redistribute personnel and/or equipment among airbases to equalize the workloads. The listing for personnel indicates the personnel type, the total number on base, and the number that are on duty and unassigned at the time the report is printed. The last data shown in Fig. 40 indicate the aircraft status, the numbers of times that aircrews were unavailable; and the number of times that ready aircraft could not be launched because of aircrew shortages.

The summary data presented in Fig. 41 provide an excellent indication of bottlenecks, and thus where extra resources could improve sortie production. Whenever an on-equipment task is delayed because of a resource shortage, or whenever a backshop job is delayed because of a shortage of personnel or equipment, a record is stored of the length of that delay; the delays are summarized here, segregated by cause. There were ten delays of on-equipment tasks because of the nonavailability of Type #23 personnel at

```
                 QUANTITIES AND TIMES FOR ON-EQUIPMENT TASKS AT BASE 1

        SHOP        1     2     3     5     7     9    10    12    25    27    28    29
    NUM TASKS     391    36    44    38    28    12    73    67   967   373   532   360
  AVG TIME-HR     2.8   2.3   4.9   1.0   6.9   1.8  15.3   2.3   0.8   0.7   0.6   0.4
  STAN DEV-HR    15.4   1.3   8.7   0.6   7.9   0.5  26.0   4.7   0.6   0.6   0.3   0.0
  MAN HRS X10      97    17    22    14    15     5    35     0     0    13   121    32
  STAND. TIME     0.3   1.9   1.2   0.9   1.9   1.6   2.6   1.1   0.4   0.0   0.0   0.0

                 QUANTITIES AND TIMES FOR OFF-EQUIPMENT REPAIRS AT BASE 1

        SHOP        2     3     5     7     9    10    12    30
  NUM REPAIRS      43    68    12    23     3    78    99   315
  AVG TIME-HR    15.4  13.3  20.0   5.5  55.1  44.7   4.4   3.8
  STAN DEV-HR    21.2  10.9   3.2   2.7  30.3  50.5   8.0   2.6
  MAN HRS X10       9    17     8    10     1    46    27   409
  STAND. TIME    22.4  19.8  18.0  10.0  13.9  19.9   1.8   0.0

                 NUMBERS OF LRUS AND SRUS PROCESSED BY AIS STATIONS

     STATION        1     2     3     4     5     6     7     8     9    10    11    12    13    14    15    16    17    18    19    20
      LRUS         27    23    34     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0

                 QUANTITIES AND TIMES FOR EQUIPMENT REPAIRS AT BASE 1

        SHOP        1     2     3     5    10
  NUM REPAIRS      22     5     3     1     3
  AVG TIME-HR    21.3  28.1   9.6  10.8  11.4
  STAN DEV-HR     6.7  39.3   7.6   0.0   3.3
  MAN HRS X10      12     0     1     0     1
                                      RESOURCES AT BASE # 1

                                         SHOP CAPACITY
 1000 1000 1000 1000 1000   1000 1000 1000 1000 1025   1000 1000 1000 1000 1000   1000 1000 1000 1000 1000   1000 1000 1000 1000


PERSONNEL     1    2    3    4    5    6    7    8   21   22   23   24   25   26   27   28   31   32   63   64   65   72   73   74
             48   16   11   12    8   32    8    8   48   16   10   12    8   32    8    8   32   10   20   80   88   10    3    4
             15    6    1    4    4   11    2    3   17    8    4    4    4   11    4    0   16    4   10   22   23    4    0    1
PERSONNEL    75   76   77   78  191  192  193  194  196
              4    5    4    8   89   96   16   40    5
              2    2    1    2   45   48    7   20    3
EQUIPMENT     2    3    4    5    6    7    8   12   15   16   17   18   20   21   22   23   25   28   30   31   32   34   80   81
              3    3    4    5    2    2    2    3    5    1    2    2    4   18    4   10    1    2    5    8    6    2    4    4
EQUIPMENT    85   86  194  195  196  197  198  199
              1    1   11    3    3    7    6    3
MUNITIONS     1    2    3    4    5    6   11   12   51   52   53   54   56
           7104 2630 1615 1049 1342 2100 2295 3923 4268 6570 7688 4168 6352
  TRAP        1    2    3    4    5
             30   10   25    9 4152
MATERIALS     1    2    3    4    5
           3516 2649 1742 2995 2000

 AIR CREWS   56   SURVIVING POL  24655   SPARE PARTS: LRU   44 SRU   24      AIRCRAFT SHELTERS: SURVIVED  21  DAMAGED  1
 CUMULATIVE AIRCRAFT KILLED / DAMAGED DURING AIRBASE ATTACKS    2    7

                                    STATUS OF AIRCRAFT AT BASE # 1
                           (AIRCRAFT NUMBER/TYPE - LAST SORTIE - WORK STATUS/SQD - HOLES)
                        STATUS:  INTERRUPTED +1;  WAITING +2;  ONGOING +4;  REQUIRED +8
           3 1    4 1    5 1    7 1    9 1   10 1   13 1   15 1   16 1   17 1   18 1   20 1   22 1   37 1   45 1   49 1   50 1   52 1   56 1
             0   5208   5694   5426      0   5686      0   5202      0      0   5490   4721   3280   4251      0   5694      0      0      0
           0 1   10 1   14 1    2 2    0 2   12 2    8 2   10 1    0 1    6 1    2 1   10 2   12 2   10 1    0 1   12 1    4 2    0 2    0 2
             0      4      1      1      0      0      0      1      0      1      1      2      0      3      0      0      0      0      0

      0                AIR CREW SHORTAGES                          READY AIRCRAFT CANCELED

       BASE 3     14    0    0    0    0    0    0    0    0          14    0    0    0    0    0    0    0    0
       BASE 4      4    0    0    0    0    0    0    0    0           4    0    0    0    0    0    0    0    0
```

Fig. 40—Shop activity and resource status at Base #1 at end of trial

Base #1; the average delay was 7.3 hours, and the standard deviation of the delays was 11.2 hours. Because personnel that assemble munitions and civil engineers are never involved in on-equipment work, there is no ambiguity if those delays are also reported here; thus, the delays for the Type #64 munitions assembly personnel are munitions assembly task delays. (Because munitions assembly tasks are defined every two hours and are purposely set aside to wait until personnel are available, moderately large average delays sometimes occur for munitions assembly personnel that are not necessarily serious; they are only serious when aircraft have had to wait for munitions—none in this case.) For the civil engineers only the number of delays is preserved, not the length of those delays (see the delays for Type #194 personnel at Base #1).

The most serious delays at Base #1 were the shortages of parts #6 and #8. Personnel and equipment generally were adequate, except for Type #77 backshop personnel that delayed 51 parts repairs an average of 15 hours. Note that part #8, which caused the most serious aircraft delays, is repaired by Type #77 personnel.

The last records available at the end of a trial are the theater-wide summary of holes, the cumulative numbers of spare parts that were "broken" at each airbase during the trial, and a *listing of aircraft spare parts* at each base. The latter includes the numbers of serviceables and reparables that are on base, as well as the number of servicables that are enroute; in this example there are three reparable Type #6 parts, and five are enroute to repair the six aircraft that were shown waiting for this part in Fig. 39.

MULTITRIAL OUTPUT STATISTICS

The last three figures in this section illustrate the results that are presented at the end of the several trials of a TSAR simulation. If PRINT, CPRINT, PPRINT, DPRINT, APRINT, TPRINT, and SCROLL are all zero, these will be the only results printed after initialization. Figure 42 shows the average sorties flown across the trials. It includes the number each day, the cumulative numbers each day, and the numbers by mission for each base on each day (and the standard deviation of each). Then the total sorties by base and in the theater are listed, with the standard deviation of each value in parentheses.

The next multitrial results are shown in Fig. 43. First is the average number of sorties launched each day during each hour at each base, averaged across all trials. This is followed by a multitrial summary of aircraft activities by base and aircraft type. A

AIRCRAFT DELAYS DUE TO RESOURCE LIMITATIONS
****
BASE 1

DELAYS DUE TO LIMITATIONS OF PERSONNEL

TYPE	3	4	8	23	25	26	28	31	32	64	194
NUM DELAYS	5	1	21	10	3	3	1	1	3	4	38
AVG DELAY-HR	0.8	1.0	1.1	7.3	1.1	0.1	0.8	2.6	6.4	1.9	0.0
STAN DEV-HR	0.5	0.0	1.0	11.2	0.6	0.1	0.0	0.0	3.8	0.0	0.0

DELAYS DUE TO LIMITATIONS OF AGE

TYPE	3	5	7	8	12	15	28	31	32	34
NUM DELAYS	14	17	6	2	1	13	10	1	28	12
AVG DELAY-HR	2.5	0.3	1.5	0.8	0.2	0.4	0.8	0.6	0.6	1.8
STAN DEV-HR	4.4	0.1	1.0	0.2	0.0	0.2	0.2	0.0	0.3	1.0

DELAYS DUE TO LIMITATIONS OF PARTS
(ALSO, REPAIR DELAYS DUE TO SRUS)
HOLES 14 HOLES/PAA 0.737 HOLES/AC WITH HOLES 1.750 HOLES/NMCS AC 1.750

									SRU	SRU
TYPE	6	8	11	12	15	16	17	20	114	141
SHOP	7	10	10	10	10	12	12	12	10	12
NUM DELAYS	17	27	6	1	1	0	1	9	3	8
AVG DELAY-HR	17.8	33.1	1.8	0.4	3.4	0.0	14.9	8.4	215.0	27.9
STAN DEV-HR	18.2	35.1	1.6	0.0	0.0	0.0	0.0	9.3	13.0	17.9
AC "HOLES"	6	0	1	1	0	1	0	5	3	3

DELAYS DUE TO LIMITATIONS OF SHOPS

TYPE	3
NUM DELAYS	3
AVG DELAY-HR	22.0
STAN DEV-HR	10.9

BASE 1

PARTS AND EQUIPMENT *REPAIR DELAYS* DUE TO LIMITATIONS OF PERSONNEL

TYPE	72	73	74	76	77	78
NUM DELAYS	1	20	28	16	51	2
AVG DELAY-HR	1.9	6.8	2.3	1.9	15.2	1.8
STAN DEV-HR	0.0	3.8	2.2	1.9	25.8	1.5

PARTS AND EQUIPMENT REPAIR DELAYS DUE TO LIMITATIONS OF AGE

TYPE	3	16	17	18	22	25	32
NUM DELAYS	3	4	2	7	1	9	1
AVG DELAY-HR	14.2	3.8	1.7	52.2	0.6	3.0	3.5
STAN DEV-HR	5.0	2.6	0.6	72.0	0.0	1.0	0.0

PARTS AT BASE # 1 (PART NUMBER - SERVICEABLES - REPARABLES - ENROUTE SERVICEABLES)

1	2	3	4	5	6	7	8	9	10	11	12	13	15	16	17	20	101	102	103
8	8	4	2	1	0	2	1	2	3	0	0	1	2	3	7	0	2	0	1
3	3	1	1	0	3	1	5	3	2	4	1	2	0	2	2	0	0	0	0
0	0	0	0	0	5	0	0	0	0	0	1	0	0	2	0	5	0	0	0

107	108	112	113	114	115	117	118	141	142	144	201	202	203	204	205	206	211	212
4	0	1	3	0	0	2	1	0	2	8	3	14	11	13	7	3	9	8
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	3	0	0	0	7	0	0	0	0	0	0	0	0	0	0

THEATER-WIDE: HOLES 27 HOLES/AIRCRAFT 0.659 HOLES/AIRCRAFT WITH HOLES 1.588 HOLES/NMCS AIRCRAFT 1.588

CUMULATIVE SENT PARTS BY BASE 347 253 1 9 0 59

Fig. 41—Summary of task delays listed by cause

OVERALL PERFORMANCE IN 3 TRIALS RUN ID# 26995 JULY 3, 1989

DAILY SORTIES FLOWN - DAILY TOTAL AND MEAN AND STANDARD DEVIATION BY MISSION AND BY BASE

DAY	TOTALS																					
1	54.7 18.1	54.7 18.1	5.0 5.1	8.3 6.5	0.0 0.0	0.0 0.0	0.0 0.0	9.3 3.1	13.7 3.1	0.0 0.0	0.0 0.0	0.0 0.0	10.7 1.7	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	7.7 0.5	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
2	52.3 6.0	107.0 18.5	8.3 6.5	9.3 3.1	0.0 0.0	0.0 0.0	0.0 0.0	6.0 0.8	9.7 5.9	0.0 0.0	0.0 0.0	0.0 0.0	9.7 2.6	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	9.3 1.2	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
3	70.7 8.6	177.7 12.3	16.7 4.0	16.7 2.5	0.0 0.0	0.0 0.0	0.0 0.0	13.7 2.9	9.7 3.4	0.0 0.0	0.0 0.0	0.0 0.0	7.0 1.4	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	7.0 1.4	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
4	78.3 9.7	256.0 3.6	21.7 3.4	20.0 2.4	0.0 0.0	0.0 0.0	0.0 0.0	12.3 4.6	19.7 2.5	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	4.7 1.2	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
5	70.3 20.4	326.3 19.9	22.0 2.9	19.3 2.5	0.0 0.0	0.0 0.0	0.0 0.0	12.0 8.8	13.0 6.5	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	4.0 2.8	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
6	75.7 6.8	402.0 26.3	18.0 3.6	16.3 6.8	0.0 0.0	0.0 0.0	0.0 0.0	16.0 2.2	9.3 2.6	0.0 0.0	0.0 0.0	0.0 0.0	9.0 1.6	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	7.0 2.9	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
7	90.0 15.3	492.0 41.6	22.3 4.8	17.3 3.3	0.0 0.0	0.0 0.0	0.0 0.0	17.0 1.4	17.7 9.5	0.0 0.0	0.0 0.0	0.0 0.0	10.0 1.4	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	5.7 1.9	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
8	80.7 27.9	572.7 65.5	18.7 5.6	15.3 4.5	0.0 0.0	0.0 0.0	0.0 0.0	15.7 10.3	15.3 7.4	0.0 0.0	0.0 0.0	0.0 0.0	8.7 1.2	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	7.0 0.8	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
9	92.7 4.1	665.3 69.0	20.3 6.1	15.3 2.6	0.0 0.0	0.0 0.0	0.0 0.0	27.0 1.4	23.7 3.7	0.0 0.0	0.0 0.0	0.0 0.0	4.7 1.9	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	1.7 0.9	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
10	96.3 5.3	761.7 69.7	24.7 0.9	16.3 0.9	0.0 0.0	0.0 0.0	0.0 0.0	30.3 1.7	25.0 3.3	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
11	79.3 3.1	841.0 72.7	17.3 1.9	16.3 2.1	0.0 0.0	0.0 0.0	0.0 0.0	26.3 4.1	19.3 2.9	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
12	68.0 6.4	909.0 66.4	18.3 2.4	12.7 4.2	0.0 0.0	0.0 0.0	0.0 0.0	23.3 2.5	13.7 4.6	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
TOTALS			213	183	0	(	0	208	189	0	0	0	59	0	0	0	0	53	0	0	0	0
STD DEV			14.1	8.4	0.0	0.0	0.0	29.8	18.9	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0

SORTIES BY BASE 397. (20.) 399. (47.) 60. (4.) 54. (3.)

AVERAGE SORTIES PER TRIAL 909.0 (66.4)

Fig. 42—Multitrial statistics: Average sorties by day, base, and mission

summary of the civil engineering work required to clear the runways and taxiways is next; in this instance Base #1 required clearance of an average of 14 UXO, 434 mines, and six craters to maintain the MOS. The remainder of Fig. 43 provides average values across all trials of various losses and other disruptive factors at each airbase.

The final multitrial results are shown in Fig. 44. The results are given for each of the 12 days of the simulation. Some items are aggregated across the theater and reported as ALL, and other items are reported by numbered base. The "sortie rate" is 100 times the average number of sorties flown during the day for each aircraft assigned at day's end. The "effectiveness" statistics are the sum of the "effectiveness proxies" (which the user may enter for each SCL on the CT12) for each sortie that is launched and does not suffer an abort. The results are divided by 100 before being printed. When the air-to-air mission type for an aircraft has been distinguished on CT15/3, the "effectiveness" for air-to-air sorties is reported separately from that for all other sorties (this feature obviously could be used to segregate any particular mission that interests the user). The record for damaged aircraft calls for a special comment. The data presented for ALL are the average cumulative numbers of aircraft that have been damaged at all bases. The data presented for the individual airbases are the average numbers of battle-damaged aircraft that remain to be repaired at the end of each day. The damaged and NMCS aircraft results normally do not sum to the numbers reported under "NMCS + BATTLE DAMAGED" because many of the holes have been consolidated onto the battle-damaged aircraft by cannibalization. The numbers of "holes per base" are reported only on those days for which these statistics were computed—i.e., every STATFQ days.

AVERAGE SORTIES LAUNCHED DURING HOUR ENDING AT:

BASE # 1

DAY	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00
1	0	0	0	0	0	3	3	0	0	3	0	0	0	0	0	0	0	0	1	3	0	0	0	0
2	0	0	0	0	0	8	6	0	0	0	1	0	0	0	0	0	0	0	3	0	1	0	0	0
3	0	0	0	0	0	4	7	1	0	0	0	0	0	6	1	0	0	0	3	10	1	0	0	0
4	0	0	0	0	0	5	10	0	0	2	1	0	2	8	2	0	0	0	5	7	0	0	0	0
5	0	0	0	0	0	3	8	0	0	3	2	0	1	11	1	0	0	0	1	12	0	0	0	0
6	0	0	0	0	0	4	5	1	0	2	1	0	4	7	1	0	0	0	2	8	0	0	0	0
7	0	0	0	0	0	2	8	1	0	4	3	0	1	10	0	0	0	0	3	8	0	0	0	0
8	0	0	0	0	0	3	7	0	0	1	2	0	3	7	0	0	0	0	1	11	0	0	0	0
9	0	0	0	0	0	3	7	0	0	3	1	0	7	2	1	0	0	0	2	10	0	0	0	0
10	0	0	0	0	0	4	8	0	0	4	2	0	2	9	1	0	0	0	6	5	0	0	0	0
11	0	0	0	0	0	3	6	0	0	4	1	0	1	8	1	0	0	0	4	6	0	0	0	0
12	0	0	0	0	0	3	6	0	0	4	1	0	2	5	1	0	0	0	4	6	0	0	0	0

MULTI-TRIAL SUMMARY OF AIRCRAFT ACTIVITIES

BASE	AC	COMBAT LOST	COMBAT DAMG	ATTACK LOST	ATTACK DAMG	ABORTS AIR	ABORTS GND	CANN	CUM NMCS			TO REAR	FR/TO FILLER	TO/FR DOB		CHECK FLTS	SORTIES BY MISSION #1	#2	#3	#4	#5
1	1	20	51	3	3	1	0	12	15	0	0	10	31	44	0	50	214	185	0	0	0
2	1	17	45	3	2	0	0	12	42	0	0	14	36	34	0	50	210	192	0	0	0
3	1	3	4	0	0	0	0	0	5	0	0	8	0	34	0	0	60	0	0	0	0
4	1	4	3	0	0	0	0	2	12	0	0	5	0	25	0	1	54	0	0	0	0
6	1	0	0	0	0	0	0	5	0	0	0	0	7	0	0	0	0	0	0	0	0

RUNWAY AND TAXIWAY CLEARANCE AND REPAIR ACTIVITIES BY BASE (AVG)

RUNWAY UXOS CLEARED	14	13	0	0	0	0
RUNWAY MINES CLEARED	434	305	0	0	0	0
RUNWAY CRATERS REPAIRED	6	9	0	0	0	0
TAXIWAY UXOS CLEARED	44	46	0	0	0	0
TAXIWAY MINES CLEARED	598	784	0	0	0	0
TAXIWAY CRATERS REPAIRED	37	28	0	0	0	0

RESOURCE STATISTICS BY BASE
AVERAGES FOR 3 TRIALS

BASE #	1	2	3	4	5	6
AIR CREWS						
LOST IN COMBAT	10	9	2	3	0	0
KILLED BY ATTACK	0	0	0	0	0	0
HOSPITALIZED BY ATTACK	0	0	0	0	0	0
MAINTENANCE AND OTHER PERSONNEL						
AVERAGE NUMBER ASSIGNED	813	800	185	185	60	89
FATALITIES	18	18	0	0	0	0
HOSPITALIZATIONS	60	55	0	0	0	0
HEAT COLLAPSE	5	11	1	2	0	0
ENTERED "COOLER"	1695	1675	473	481	0	33
MAN-HRS IN HOSPITAL	9602	9962	34	56	0	0
MAN-HRS IN "COOLER"	428	585	160	164	0	11
MAN-HRS IN QUEUE	0	0	0	0	0	0
MATERIAL LOSSES						
AIRCRAFT						
LOST IN COMBAT	15	14	3	3	0	0
DESTROYED IN ATTACK	3	3	0	0	0	0
DAMAGED BY ATTACK	3	2	0	0	0	0
EQUIPMENT LOST	13	18	0	0	0	0
SPARE PARTS LOST	1	0	0	0	0	0
MUNITIONS LOST	426	199	0	0	0	0

Fig. 43—Multitrial statistics: Sorties launched each hour, runway clearance summary, and resource status data

```
                  ASSIGNED AIRCRAFT
ALL    49  52  49  50  52   54  55  52  47  44   42  40
 1     18  18  24  22  22   19  18  19  19  19   18  17
 2     14  16  16  25  25   23  22  20  21  19   18  17
 3      6   6   1   0   0    4   4   2   1   0    0   0
 4      7   6   4   0   2    3   3   3   0   0    0   0
 5      0   0   0   0   0    0   0   0   0   0    0   0
 6      4   6   4   3   4    5   8   7   6   6    5   6

                  SORTIE RATE  (X 100)
ALL   112 101 144 157 135  140 164 155 197 219  189 170
 1     74  98 139 189 188  181 220 179 188 216  187 182
 2    164  98 146 128 100  110 158 155 241 291  254 218
 3    178 161 700   0   0  225 250 433 467   0    0   0
 4    110 156 175   0 200  233 189 233   0   0    0   0
 5      0   0   0   0   0    0   0   0   0   0    0   0
 6      0   0   0   0   0    0   0   0   0   0    0   0

                  CUMULATIVE THEATER EFFECTIVENESS (/100)
ALL    64 118 192 274 348  427 522 607 704 806  889 961
0                        DAILY EFFECTIVENESS** BY BASE (/100)
 1      7   9  18  24  24   20  25  20  22  27   19  20
 2     11   7  14  14  13   18  18  17  30  33   29  25
 3     12  11   8   0   0   10  11  10   5   0    0   0
 4      8   9   8   5   5    8   6   8   2   0    0   0

                  DAILY A-A EFFECTIVENESS BY BASE (/100)
 1     10   9  17  20  19   16  17  15  15  16   16  13
 2     16  10  10  19  13    9  18  15  24  25   19  14
 3      0   0   0   0   0    0   0   0   0   0    0   0
 4      0   0   0   0   0    0   0   0   0   0    0   0

                  LOST AIRCRAFT
ALL     7  12  20  23  28   32  34  38  42  46   48  50

                  DAMAGED AIRCRAFT
ALL    13  22  32  41  52   58  69  77  85  91   97 103
 1      3   2   4   6   6    2   3   4   4   6    3   4
 2      3   3   4   3   3    3   2   2   2   0    1   2
 3      1   1   0   0   0    0   0   0   0   0    0   0
 4      1   0   1   0   0    0   0   0   0   0    0   0
 5      0   0   0   0   0    0   0   0   0   0    0   0
 6      3   3   2   2   3    4   7   6   5   5    5   5

                  NMCS AIRCRAFT
ALL     2   5   5   5   9   10  14  11  11  12   12  12
 1      0   2   2   2   4    3   5   4   4   5    5   5
 2      1   0   0   0   1    2   2   2   3   4    3   5
 3      0   1   0   0   0    0   1   1   0   0    0   0
 4      1   1   1   0   1    2   1   1   0   0    0   0
 5      0   0   0   0   0    0   0   0   0   0    0   0
 6      0   1   2   2   2    3   5   4   3   3    4   3

                  NMCS + BATTLE DAMAGED AIRCRAFT BY BASE
 1      2   3   5   7   9    5   7   6   7   9    7   7
 2      3   3   4   3   5    5   4   4   5   5    5   6
 3      1   2   0   0   0    0   1   1   0   0    0   0
 4      2   1   2   0   1    2   1   1   0   0    0   0
 5      0   0   0   0   0    0   0   0   0   0    0   0
 6      3   3   3   3   3    4   7   6   5   5    5   5

                  NMCS HOURS
ALL     9  59 160 271 387  570 785106112871501 17592033
 1      0   8  44  87 144  224 285 371 448 530  633 744
 2      1  12  15  18  18   45  86 133 183 237  310 386
 3      1   6  13  16  16   16  20  37  59  64   64  64
 4      6  19  43  64  75   96 133 159 165 165  165 165
 5      0   0   0   0   0    0   0   0   0   0    0   0
 6      1  14  45  86 134  189 261 361 432 505  587 674

                  TOTAL HOLES PER BASE
 1      0   0   0   0   0    0   0   0   0   0    0   0
 2      0   0   0   0   0    0   0   0   0   0    0   0
 3      0   0   0   0   0    0   0   0   0   0    0   0
 4      0   0   0   0   0    0   0   0   0   0    0   0
 5      0   0   0   0   0    0   0   0   0   0    0   0
 6      0   0   0   0   0    0   0   0   0   0    0   0

                  CANNIBALIZATIONS PER BASE
 1      0   0   0   0   1    2   3   4   6   8    8  12
 2      0   0   0   0   0    0   0   3   4   5   10  12
 3      0   0   0   0   0    0   0   0   0   0    0   0
 4      0   1   1   1   1    1   2   2   2   2    2   2
 5      0   0   0   0   0    0   0   0   0   0    0   0
 6      0   0   1   1   2    2   3   3   3   4    4   5

                  EXPEDITED REPAIRS PER BASE
 1      0   2   3   4   8   12  15  20  25  28   29  32
 2      0   0   1   1   2    4   5   9  11  17   22  24
 3      0   0   0   0   0    0   0   0   0   0    0   0
 4      0   0   0   0   0    0   0   0   0   0    0   0
 5      0   0   0   0   0    0   0   0   0   0    0   0
 6      0   0   0   0   0    0   0   0   0   0    0   0

                             COMPUTER TIME:  114.025 SEC
```

Fig. 44—Multitrial statistics: Daily averages of key performance indicators

XXII. CHECKLIST FOR TSAR INPUT DATA REQUIREMENTS

This section has been created in response to requests for a short checklist, or cross-reference, that will help those who are preparing or modifying TSAR input datasets to be better able to provide all the data required. Although no short list can guarantee to do that, this list may help users avoid some pitfalls. Used in conjunction with a set of TSAR format reproductions, this checklist should provide useful guidance for structuring TSAR data bases.

For the sake of brevity, few explanations are offered with this list; the user should refer to Sec. XIX or Vol. I for more detail on the comments provided here. In many instances cards are specified as optional, but that should not be interpreted to mean that the control variables entered on that card are inoperative, because in many cases a zero (or null) entry is an operationally meaningful value. This section uses the special notation DV(NTRIAL) = 1 to say that the default value of NTRIAL is 1. Unless otherwise noted, the default value for a blank (or omitted) entry is zero.

Card Type	Data Requirements
	KEY TSAR CONTROL VARIABLES
1	This card is mandatory, and a value for SIMLTH is mandatory. DV(NTRIAL) = 1, DV(NTYPE) = MAXT, DV(NBASE) = MAXB. Zero (or null) entries for all other entries are permissible. NBASE should include EMERG and rear maintenance bases; initialize SEED for reproducibility.
2/1	This card is optional. If TEST = −1, a special card must follow. If PRINT = 0, only the multitrial results will be printed. If STATFQ = 0, statistics will not be collected.
2/2	This card is optional; a "−1" in the appropriate column disengages the associated special random number stream.
2/3	Used only for special tests.
2/4	Aircraft status and deferred task reports are optional.
2/5	Optional output controls. If RPRINT = 0 the special runway output is suppressed; DPRINT controls the aircraft status and deferred task data specified with CT2/4. When DOPOST is initialized, a supplementary card is mandatory immediately following CT2/5.

2/6 Used only to print heap and queue contents at specific times.

3/1 This card is optional. DV(OPSBSE) = NBASE, DV(LTHDEF) = 10000, DV(MXHOLE) = 10000, DV(DOCANN) = 10000, DV(CANMUL) = 150.

3/2 This card is optional. DV(MNTLMT) = 20000, DV(MNTF) = 100, DV(MNTR) = 100, DV(NEWDTA) = 100.

3/3 This optional card controls the automatic parts generation features.

3/4 When USECW > 0 all entries except IWARN, WARN, VARMOP, and CPRINT are mandatory. If CPRINT = 0, special CW reports are suppressed.

3/5 This card is mandatory if USECW > 0 but has no mandatory entries. If DELTA = 0, times to cool off will be excessive.

3/6 This card is optional. DV(STOPCW) = 32750 TTU.

3/7 These ensemble characteristics are necessary when Types #2 or #3 ensembles are specified on CT17/3.

4/1 This card is optional. DV(LOADTM) = 2400, DV(LSTTOD) = 2400, DV(PROTME) = 30. ENDAY should be late in day, and if CREWS > 0 SLEEP must be specified.

4/2 The features on this card are optional. DV(MULTI1) = 100, DV(MULTI2) = 100, DV(NOCANN) = 1000.

4/3 These optional control variables are operative only with DOBs.

4/4 This card is optional; it provides auxiliary variables for test purposes. (SPARE4, SPARE5, SPARE7 currently actuate special tests—see subroutine INPUT.)

AIRCRAFT TASK AND BACK SHOP REPAIR REQUIREMENTS

5 Except for the refueling task (see CT15/1), these cards are optional; however, if not used, the only work that will be done on aircraft is refueling and loading mission-dependent munitions. If only one personnel team is specified it must be listed in columns 21–25, and if only one equipment is specified it must be listed in columns 31–33. Munitions and TRAP are specified with "part" numbers 10000 + and 20000 + 400 × Number + Type, respectively (see Sec. XIX). DV(Criticality number) = 32.

6 Alternate task procedures are optional. Single teams are entered in columns 16–20 (and 51–55) and single equipments in columns 26–28 (and 61–63). The special CT6/88 and CT6/99 cards are also optional.

7 These cards are required if tasks are to be included in the shop task collections discussed in Sec. IV, Vol. I. At least one CT5 is required for each task specified on a CT7. The probabilities that tasks are not detected by the aircrews before landing are operative only when DOBs are specified.

8 A CT8 is required for each part, LRU, and SRU, unless the NRTS rate is 101 for all bases. If an AIS station is specified as a required equipment, it must be entered as AGE1 (columns 26–30).

9 Alternate parts repair procedures are optional, as are the special aids provided with the CT9/88 and CT9/99 cards.

10 Equipment breakrates and repair procedures are only required for those equipment types that malfunction and require repair.

MUNITIONS ASSEMBLY AND LOADING REQUIREMENTS

11/1 Munitions assembly requirements are not required if BUILD = 0. If the assembly locations of guided and unguided munitions are to be distinguished, the type number for unguided munitions should be preceded by a minus sign.

11/2 Munitions component data are required only if unassembled munitions are to be made up of components.

12 Standard Combat Load (SCL) data are mandatory for each aircraft type and mission type that is to be simulated, and at least one SCL number must be entered for each combination. DV(Value) = 100.

13 Mission-dependent munitions loading requirements are mandatory for each SCL listed in CT12, and a configuration number in columns 6–9 is mandatory.

14 Aircraft reconfiguration requirements data are mandatory for each configuration number listed in CT13.

AIRCRAFT AND MISSION DATA

15/1 This aircraft descriptor card is mandatory, but only the fuel quantity, fueling task number, number of missions, and the "nominal times" are mandatory.

15/2 This card is optional. The battle damage task-list applies to all missions, if not overridden in CT15/3. Spares for battle damage tasks are generated automatically by the entry in columns 41–45. If there are no entries in columns 66–80 corresponding to each "basic munition" on CT15/1, aircraft will not be permitted to fly if those munitions are unavailable.

15/3 All entries are optional. If task numbers are entered for hot-pit refueling or decontamination, a corresponding CT5 is mandatory. Battle damage task-lists for specific missions override the entry on CT15/2.

15/4 Phase inspections are optional. If two or more frequencies are entered, they must be entered in order of increasing infrequency; e.g., 50 hours, 150 hours, and 300 hours phase inspections.

15/5 These data are optional, as are those on CT15/88.

16 The mission description entries in columns 3–5, 6–7, 11–14, and 51–55 are mandatory for each aircraft/mission combination specified by a CT12. To specify no attrition, enter 60 0 in columns 51–55.

AIRBASE DESCRIPTIVE DATA

17/1	Key base descriptors in columns 6–10 and 11–15 are mandatory. DV(POL capacity) = 32750.
17/2	Task time modifier data are optional. DV(HURRY) = 100, DV(REDUCE) = 0, DV(SAVE) = 0.
17/3	Key airbase structural data in columns 6–25 are mandatory, and the entries in columns 26–35 are mandatory if base attacks are to be simulated. An entry is mandatory in columns 51–55 if early morning inspections are desired, and the chemical ensemble worn on the base (columns 56–60) is mandatory when USECW > 0.
17/4	A taxiway network description is mandatory if attacks against the runways or taxiway network are to be simulated.
17/5	Aircraft shelter location data are mandatory if aircraft in shelters are to be at risk to attack.
17/6	Runway arc data are mandatory if attacks against the runways are simulated.
17/7	These runway/taxiway repair features are optional.
17/8	Data for at least one ramp is mandatory if attacks are simulated.
17/9	These special delays and base location data are optional.
17/10	Specifications of variable damage to "all other" resources are optional.
17/11	An entry in columns 11–15 on card #1 is mandatory if DOATC = 1; if these capabilities are to be affected by attacks, at least one other card must be used.
18/1	If these cards are omitted, all "day" shifts begin at midnight, and shelter doors are always closed at attack time.
18/2	Breakrate modifiers are optional. DV(Entry) = 100.
19	Use of the TSAR task incompatibility features is optional.

INITIAL BASE STOCK LEVELS

20	Initial aircraft inventories are mandatory, and they must precede CT41 and CT42. "Crews" are mandatory if CREWS = 1. DV(Sq) = 1.
20/66	Aircraft transfer directives used with DOBs are optional.
20/77	Filler aircraft in the theater are optional.
20/99	Limits on CONUS aircraft stocks are optional.
	The special CT2x/88 cards directing that resource stocks already specified for one base be duplicated at another, and the CT2x/99 cards that limit the resource replacements available in CONUS are optional for CT21 through CT26.
2x	When the base number is omitted for a CT21 through CT26, the specified stocks will be placed at all bases.

21	All entries are required for those personnel types that are specified for any of the several types of tasks, if that work is to be conducted at a base. "Min Size" should equal the size of the largest team of this personnel type used on any task.
22	All entries are required for those equipments that are specified for any of the several types of tasks, if that work is to be conducted at a base.
22/66	One of these cards is mandatory for each type of AIS station; all entries are mandatory except "Prob," and "Maintenance Time for more than one station."
22/77	Conditional probabilities should be entered for each "TRAY" that is assigned (see CT23/78).
23	These cards are used to provide spare parts stocks when OUTFIT = 0 and may be used to modify the stocks provided, when OUTFIT > 0.
23/2xx	NRTS data are mandatory when OUTFIT > 0. If NRTS = 101, no shop check will be required. DV(NRTS) = 0 if card with part is entered; DV(NRTS) = 101 if card not entered.
23/3xx	NRTS data that apply when there is a CIRF are mandatory if CIRF = 1.
23/66	Parts cost data are optional (and will not affect the simulation) unless PMODE = 1 or TOOFEW < 0.
23/70	Basic parts procurement policy data are mandatory for each base that will operate or service aircraft when OUTFIT > 0.
23/72	Safety factors are optional; normally the USAF provisions spare parts with "safety factors" on the order of 100.
23/74	Bases for lateral resupply are optional.
23/76	Duplication of the NRTS rates for one base at another is optional.
23/78	TRAY assignments are mandatory when AIS equipments are simulated.
23/88	A CT23/88 duplicates only those parts that have already been specified with a basic CT23; parts generated by OUTFIT are unaffected.
24	Munitions stocks are optional, but are required if sorties are not to be canceled for lack of munitions. Unassembled munitions are designated by adding 500 to the munition number; components must be entered if munitions specified on CT11/2 are to be built.
25	TRAP stocks are optional but are required if sorties are not to to be canceled for lack of TRAP specified on CT14 (or CT5).
26	Building material stocks are optional, but are required for reconstruction activity to occur when CT38 specify building materials.
27	POL is mandatory for all bases that will operate aircraft.
28	Aircraft parts lists are optional; these data are used only to control which parts are eligible for "salvage."

AIRCRAFT MAINTENANCE SCHEDULING DATA

29 These cards are mandatory for each type of aircraft that will operate at each base, except rear maintenance bases. (If Base = 0, all bases are defined the same.) Entries for Shops #26 and #29 are mandatory at operational bases, and an entry for task 30000 is required for ABDR. Shop #25 denotes when mission-dependent postflight inspections are to be accomplished. Entries for Shops #27 or #28 are not permitted. The CT29 for the EMERG base must include Shop #29, omit Shop #26, and conclude with Shop #30. CT29 is not required for rear maintenance bases.

29/88 These optional entries specify the probabilities that tasks entered with CT29 are not detected before landing.

30 Flyable weather data are optional; DV(WX) = flyable.

SHIPPING SCHEDULES, ETC.

31 Scheduled CONUS shipments are optional.

32/1 Intratheater transportation schedules are required to establish an intratheater transportation system.

32/2 CT32/2 corresponding to the transit links specified by CT32/1 are mandatory; only the transit time is mandatory. DV(ArrPr) = 100.

33 Replacements for losses sustained in combat or during attack are optional.

34 Spare parts disposition locations are mandatory if spare parts are represented.

35/1 Specific cannibalization times and restrictions are optional.

35/2 Breakrates for cannibalized parts are optional.

35/3 These cards are required for parts that must be repaired using an AIS that is in the "parent" shop of a distributed shop, if that shop may be damaged in an attack.

35/4 These cards are only required when a part is used in more than one location (i.e., when QPA > 1).

35/5 These cards are optional.

36 Resource reporting schedules are required only if STATE > 0.

BASE ENGINEER PROCEDURES

37 Facility descriptor data are required if USECW > 0 or if attacks are to occur. The entries in columns 21–40 and 56–75 are optional; the others are mandatory. Setting SIZE = 0 specifies that no attempt is to be made to repair the given facility.

37/xx If runway and taxiway clearance are to be required for the simulation, entries defining repair procedures are mandatory.

38 Base engineer task requirements are mandatory for all Task Types specified by CT37 when CEWORK = 1. All entries are optional except Task Type and both components of Time.

39 Building repair priorities are mandatory when CEWORK = 1. If Base is omitted, all bases will have the same priorities.

39/99 Specification of additional personnel loss rates is optional.

AIRBASE ATTACK DATA

40 These cards are used only when attacks are to be sustained. Many restrictions apply unless CT40 are generated by TSARINA. See CT40 in Sec. XIX, Vol. II, and App. J, Vol. III. When the CT40 generated by TSARINA are stored in a separate data set, a CT40 with 888 in columns 3–5 signals that damage data are to be read in for each trial; if the value is 777, the damage data read in from TSARINA Trial #1 will be used for all TSAR trials.

AIRCRAFT STATUS INITIALIZATION

41 These cards are mandatory. The order in which the mission assignments are specified with CT41 must be identical to the order aircraft are entered with the CT20. All CT20, CT24, and CT25 must be entered before any CT41.

42 These cards specify the maintenance that is unfinished at zero time; CT42 must follow CT41. All CT42 are optional.

CHEMICAL WARFARE DATA

43/1 Ensemble heat transfer data are mandatory if USECW > 0. Entries are required for all relevant MOPPs.

43/2 Twenty-four-hour weather data are mandatory when USECW > 0 for each meteorological condition that is to be specified.

43/3 Work slowdown data are mandatory for all relevant MOPPs and MVDCs when USECW > 0.

43/4 Times to don the ensemble are mandatory unless ensembles are to be donned instantaneously.

43/5 Hospitalization time distributions are mandatory if RECUP > 0.

43/6 These cards define CPSs and are optional. If Base is zero, all bases will use the same CPS descriptors.

43/7 The criteria and constraints data on the CT43/7 and CT43/8
43/8 are mandatory when USECW > 0 and NOVOGT = 0 (see CT3/5).

44/1 If USECW > 0, these cards are mandatory for each CWTYPE referred to in CT37. Temp is optional (zero implies ambient), but all other entries are mandatory for each agent involved in the simulation when USECW = 2.

44/2 The CWTYPE for each TSARINA target type is mandatory when USECW > 0.

44/3 Toxicity data are mandatory for each agent and MOPP involved in the simulation when USECW = 2.

44/4 Agent concentration threshold data are mandatory for each agent that is used in the simulation when USECW = 2.

44/5 These cards are relevant only when DOBUDY > 0; if not entered, only other members of the work crew will be used for Buddy care.

PERSONNEL AND EQUIPMENT UTILIZATION DATA

45/1 These cards are required when the same type of personnel is to be assigned to different organizations within a POMO organization. Equivalent personnel types must be assigned to the same shop on CT21.

45/2 Cross-training is optional. Cross-trained personnel are eligible for specified tasks (see personnel substitutability on CT5, CT8, CT10, CT11, CT13, and CT14) at designated bases (columns 21–25 on CT17/1).

45/3 Task-assist-qualified training is optional. Task-assist qualified personnel are eligible for specified tasks (see personnel substitutability on CT5, CT8, CT10, CT11, CT13, and CT14) at designated bases (columns 26–30 on CT17/1).

46 These cards are required when the same type of equipment is to be assigned to different organizations within a POMO organization. Equivalent equipment types must be assigned to the same shop on CT22.

MISCELLANEOUS DATA

47 Administrative delays for parts and equipment repairs are optional.

48 Parts repair time modifications for a CIRF are optional, and these data are only used when CIRF = 1. DV(modifier) = 100.

49 User-specified control variable changes are optional.

AIRCRAFT SORTIE DEMAND DATA, ETC.

50 At least one demand for aircraft sorties is mandatory.

60 Changes to the intratheater transportation schedules are optional.

Although the data input requirements for TSAR can appear almost overwhelming, TSAR will function correctly on very simple problems that use very few of the many features that are offered. Using the input data set listed below, TSAR quickly simulated two trials of five days each, with demands for 128 sorties per day for the 24 aircraft at Base #1 (averaging 9600 sorties/CPU minute on an IBM 370/3032). Because values for the print controls were not entered, all print controls were interpreted as zero and only the final results for each trial and the multitrial output were printed.

```
        [ blank ]
 1  0    5    2    0    1    1    1
 2  2   -1
 5   1 29      0    5                                                         1
12       1    1    1    1
13  1   1   5
14  1  5
15  1    1   0    0     1    1    1   30   90
16  1 1  0  60   0   0   0   0    0    0    0    060  0
17  1    1    1
17  3    1    0    0    1    1
20  1   1    24
27       1 5000
29  1    1    1   29    0   26    0    0
41  1 1 24
99
        [ blank ]
50  1    1    1    1    1         8    4   24               600    8  600
50  2    1    1    1    1         8    4   24              1200    8  600
99 60
```